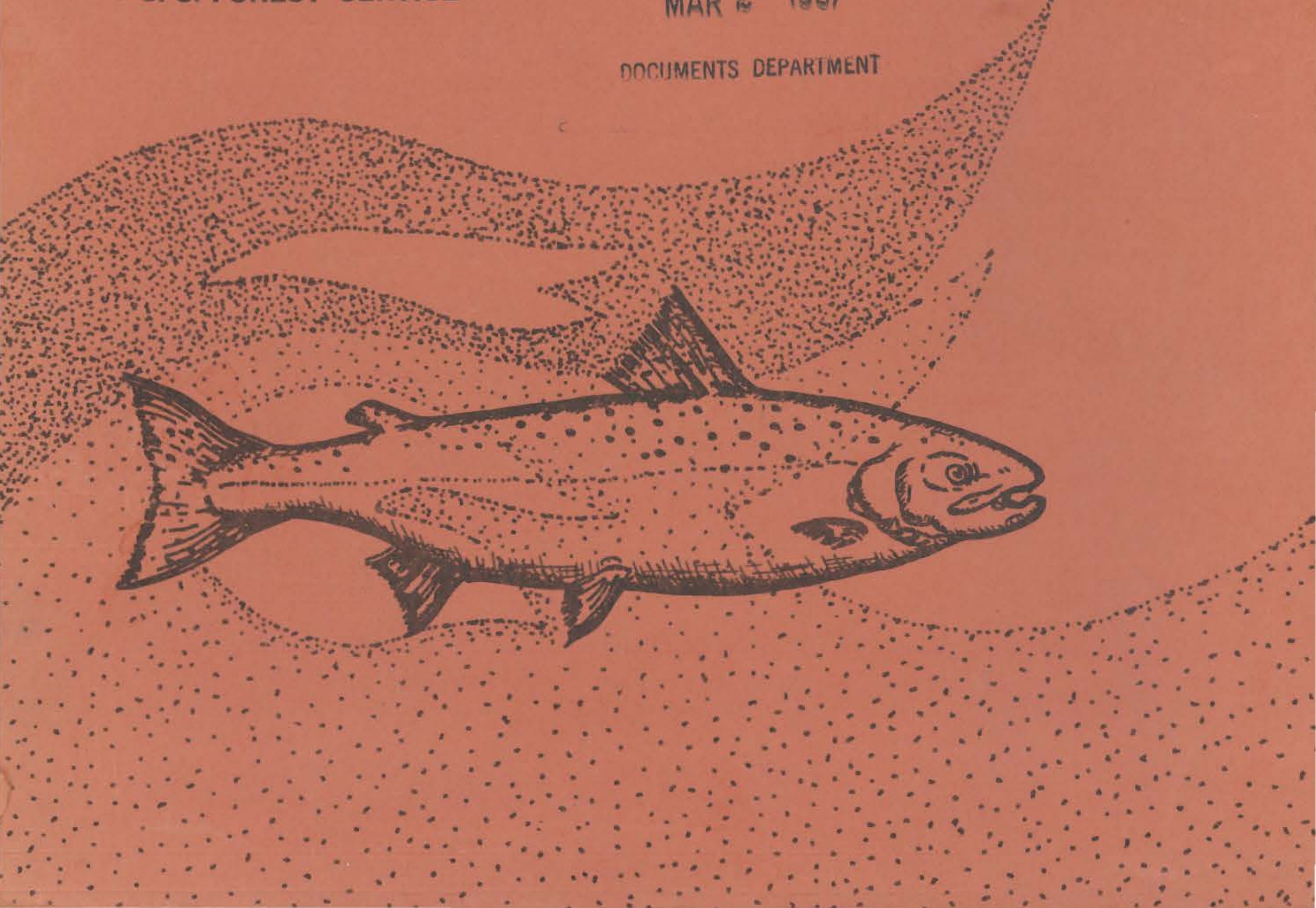
H. J. McKIRDY

SEDIMENT IN A SALMON STEELHEAD ENVIRONMENT

PROGRESS REPORT II
NOVEMBER 1972

WILLIAM S. PLATTS
ZONE FISHERY BIOLOGIST
U. S. FOREST SERVICE



AQUATIC ENVIRONMENT AND FISHERY STUDY SOUTH FORK SALMON RIVER, IDAHO, WITH EVALUATION OF SEDIMENT INFLUENCES

Progress Report II
November 1972

William S. Platts
Zone Fishery Biologist
U. S. Forest Service

CONTENTS

CONTENTS (Continued)

AQUATIC ENVIRONMENT AND FISHERY STUDY SOUTH FORK SALMON RIVER, IDAHO, WITH EVALUATION OF SEDIMENT INFLUENCES

Progress Report II
November 1972

William S. Platts
Zone Fishery Biologist

ABSTRACT

The South Fork Salmon River (SFSR) aquatic environment steadily degraded in quality, due to accelerated sedimentation from disturbed lands. Most of the degradation occurred between 1962 and 1965. Prior to 1952, the drainage was in good aquatic environmental condition.

During 1952-1965, the SFSR was incapable of discharging the accrued bedload sediment as fast as it was being recruited. This period corresponded with the increase in logging and road construction activities. The result of these activities caused accrued bedload sediment to overwhelm and destroy much of the SFSR aquatic environment and some tributaries. During 1966-1971, The SFSR gained the capability of discharging, from its system, sediment equal to that being accrued from the watershed, plus portions of the sediment contained within the channel. During this period, there was decreased logging and road construction which finalized to a non-log moritorium.

Based on related studies, the heavy accumulation of fines have degraded the SFSR aquatic environment by lowering the permeability of the materials in the spawning areas and covering the food-producing riffle areas. It also eliminated rearing and overwintering areas and formed blankets of impenetrable sediment on the surface and within the salmonid spawning areas.

Without any large storms and no additional logging or other factors causing disturbed lands, along with rehabilitation of the present road system and logged areas, the system should return to near-natural status within the next decade. The SFSR, due to the curing of the disturbed lands, would take a storm equivalent to those received in 1964 and 1965 without the massive destruction to the river environment it previously received when the watershed was in such a tender position. The river has well demonstrated that if abnormal stress is not placed on the system, it is very capable of taking care of itself.

FIGURES

TABLES

TABLES (continued)

PHOTOGRAPHS

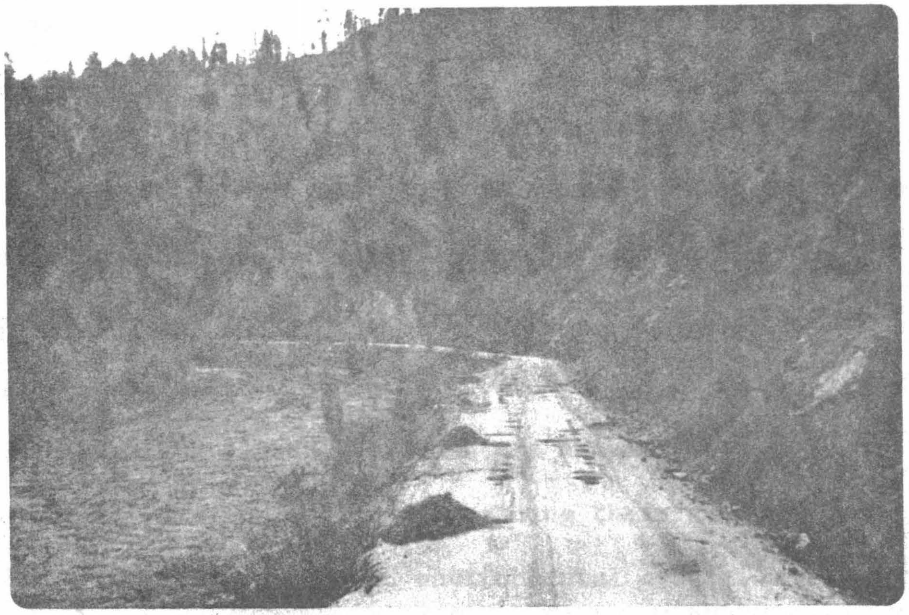
PHOTOGRAPHS (continued)

INTRODUCTION

The reader should refer to Progress Report I (Platts, 1968) for more background information on past conditions of the river during 1962 through 1967. Much of Progress Report I, however, appears in this report, so Report II will be understandable by itself. For a stream and study area description, refer to Appendix II. Unfamiliar terminology is in the Glossary in Appendix IV.

The South Fork Salmon River Special Survey was initiated in 1965 as a cooperative study between the U. S. Forest Service and the Idaho Fish and Game Department. The original study was initiated in October 1966. Major aquatic work was begun in September 1967, and the first study was submitted March 1968. This study very thoroughly documented the undesirable conditions that were present in the SFSR.

The major purposes of the studies were to determine the status of the aquatic environment, and any remedial measures that could be taken to maintain or enhance this environment. Report I (1968) and II (1972) were written to fulfill these purposes.



Photograph 1 - Main SFSR road above Krassel in 1967 (spring). Poor road maintenance has caused raw, exposed areas to stay in this condition.

Photograph 2 - Main SFSR road above Krassel in 1972 (summer). Note the vegetative gains on disturbed materials due to better road maintenance.

It had been apparent that during the past (1952-1967), the aquatic environment had steadily degraded. This justified a cause for concern as the valuable anadromous runs of salmon (Oncorhynchus tschawytscha - Walbaum) and steelhead (Salmo gairdneri - Richardson) and the resident game fish populations were declining in the SFSR. The decline of the summer chinook salmon run into the SFSR caused great concern because "summers" are a race having an especially difficult time maintaining their numbers in the Columbia River system due to changed environmental conditions (Figure 1).

The major causes of death or low production in anadromous salmon, steelhead trout, and resident salmonid populations can be summed up in five areas. Items 1 and 2 have less influence on the fishery resource within the study area. Items 3, 4, and 5 are the major limiting factors to salmonid populations.

1. Reduction of population size by extreme floods.
2. The status of water levels during early stages of incubation and its effects on the survival of deposited eggs.
3. The low rate of permeability of the intragravel waters in the spawning area and resulting fry production.
4. The loss of carrying capacity due to decreased rearing and production potential from adverse conditions within the watershed.
5. Restriction of passage and access of both adults and juveniles between their rearing and spawning areas.

The past 14 years (1957-1971), there has been a decline in the number of summer chinook salmon entering the Columbia River drainage (Annual Fish Passage Reports). The major decline was from 1957 to 1964. Since 1964, it has tended to level off at about 90,000 fish. During the past 9 years

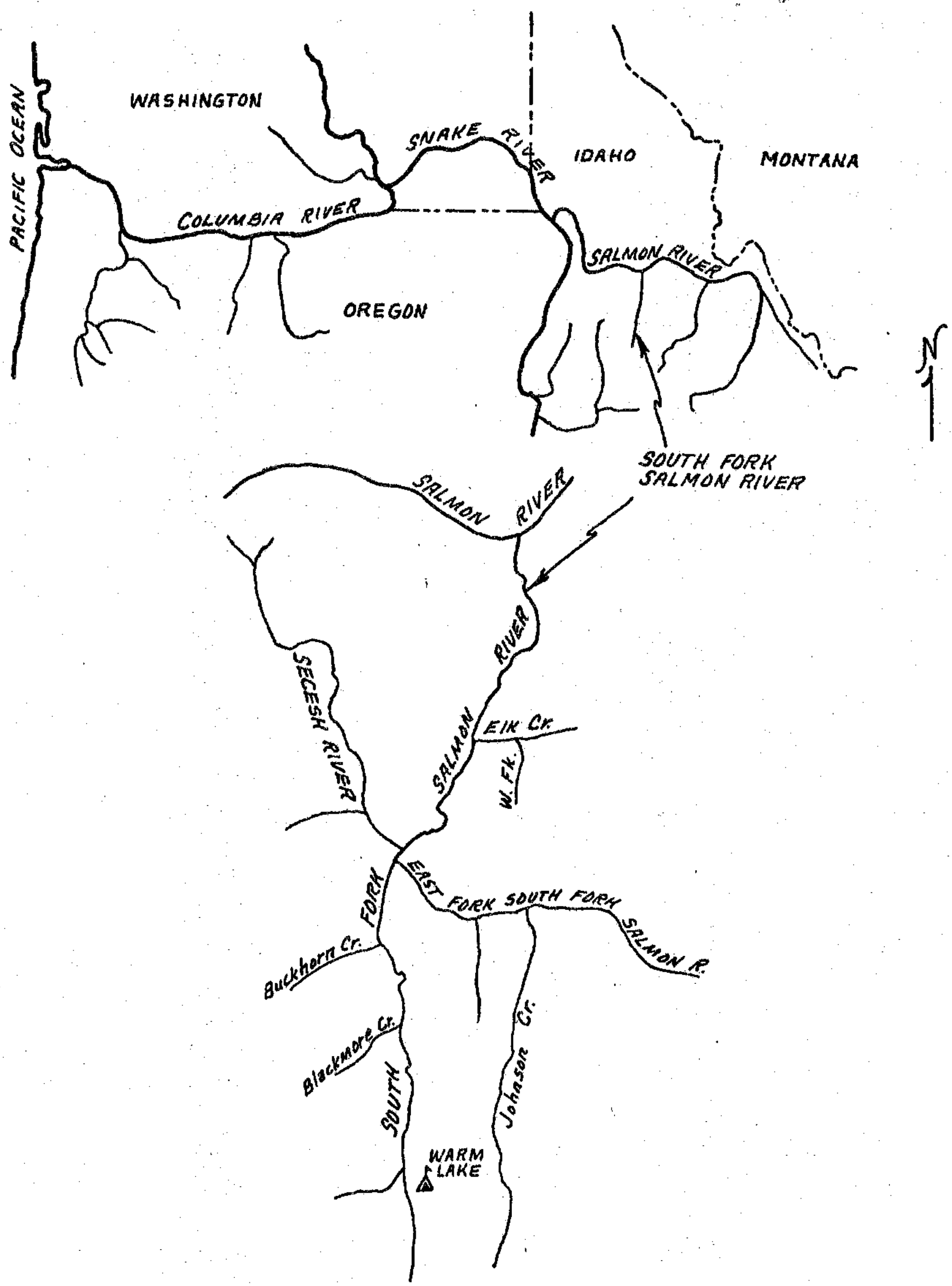


FIGURE 1
A PORTION OF THE COLUMBIA RIVER DRAINAGE WITH THE LOCATION AND FURTHER EXPANSION OF THE SOUTH FORK OF THE SALMON RIVER.

(1963-1971) there has not been adequate escapement (32,000 minimum) of summer chinook salmon past Ice Harbor Dam to provide a sport fishery and an adequate spawning escapement in Idaho waters (Table 1). The agencies managing the sport and commercial fisheries in Oregon, Washington, and Idaho have restricted or closed most of the Columbia River and its tributaries to fishing for summer chinook salmon to provide a more adequate escapement into the spawning areas. There has been no salmon fishing in the SFSR since 1964, except one year when the river was open below the confluence of the Secesh.

In some phases of the summer chinook salmon's life cycle, certain limiting factors or combinations, as stated previously, are steadily depleting the salmon numbers. The hydroelectric complexes in the Lower Columbia and Snake River systems have had adverse impacts on both the adult and juvenile stages. The 1964 status report of the Columbia River Commercial Fisheries stated that the limiting factors suppressing this racial group were occurring in the juvenile fish after the adult spawning phase produced them. This means that they believe upstream rearing and spawning areas and downstream movement of the young migrants were causing limiting mortalities and not the ocean environment.

There is considerable evidence to show that salmon and other salmonid productions are often governed by the extent and condition of the fresh water rearing area. Wickett (1958), in his extensive study of certain environmental factors affecting salmon production, stated that ocean factors

Table 1 Yearly count of summer chinook salmon entering the Columbia River and passing over Bonneville, McNary, and Ice Harbor Dams and the South Fork Salmon River Weir.

Year	Columbia Entrance	Bonneville	McNary	Ice Harbor	SFSR Weir	SFSR Redds
1938	122,647	14,777				
1939	191,870	23,430				
1940	112,674	21,965				
1941	106,471	16,408				
1942	94,869	24,637				
1943	57,029	13,484				
1944	67,090	12,604				
1945	52,633	27,610				
1946	72,049	51,220				
1947	36,265	33,860				
1948	86,896	67,237				
1949	57,783	46,732				
1950	69,350	49,604				
1951	116,397	79,283				
1952	114,452	84,291				
1953	94,973	57,821				
1954	114,751	79,397	61,065			
1955	147,683	82,939	71,180			2,746
1956	195,202	101,200	90,335		*5,043	2,067
1957	206,995	135,033	122,578			2,756
1958	187,497	101,899	73,654			1,217
1959	169,737	88,952	74,985			1,305
1960	142,606	85,170	76,940		*3,920	2,306
1961	129,164	66,461	45,257		*4,344	1,058
1962	108,022	77,485	52,756	30,639	*5,713	1,589
1963	100,016	64,041	44,760	20,875	*3,924	1,057
1964	91,137	80,531	55,062	24,696	2,895	1,124
1965	75,974	79,997	45,412	14,690	2,000	656
1966	71,997	71,997	60,827	16,983	3,300	980
1967	95,659	95,659	59,975	30,315	3,065	854
1968	89,463	82,919	60,639	29,531	-	515
1969	106,162	102,153	63,953	30,917	-	636
1970	74,700	64,902	43,359	19,382	-	527
1971	90,000	77,911	59,129	26,606	-	421
1972	77,400	71,308	69,123	22,820	-	577
AVERAGE	107,932	63,997	64,788	24,314	3,800	1,244

*Estimate

are variables in production, but the major and most frequent causes of reduced stocks are in the fresh water environment.

During the past few years, the production rate for summer chinook has been lower than any other race of chinook salmon in the Columbia River drainage and is no more than holding its own (Status Report - Columbia River Commercial Fisheries, 1964-1971). For the past few years, each summer chinook spawner (male and female) produces only one returning adult to the spawning area. This, in the past, has not allowed an adequate surplus for sport and commercial fishing. Thus, a self-replenishing annual resource that should be contributing to its full capability each year to the economy of the Pacific Northwest is failing to do so.

The Salmon River drainage is the largest remaining producer of summer chinook salmon in the Columbia River watershed. Tagging studies and observations have shown that the chinook salmon runs into the SFSR are made up exclusively of summer run fish (Richards, 1963). A large portion of these fish destined for Idaho spawn in the SFSR. This stream, during the past few years, also accounts for about 20 percent of the total salmon redds counted in Idaho. On the basis of redd counts, this makes it the most important single salmon spawning drainage in Idaho. This river also supports valuable anadromous steelhead trout and resident game fish populations. Because this stream offers an important fishery resource, any activities or influences that are or could be deleterious to the aquatic environment need careful attention.

HISTORY

Prior to 1952, the drainage was in good aquatic environmental condition, and did not always contain an overbundance of fines. (Based on Croft, 1950, size of anadromous runs and personal observations by Fritzer). From about 1958 through 1965, the river and some of its tributaries received heavy increased sediment loads, mainly from roads associated with logging operations (Table 2). In the Upper SFSR (25 miles), from 1962 through 1967, fines increased about 100 percent. The 1971 studies showed there was no reduction in fines in the 25 miles from the headwaters downstream to the Boise Forest boundary from 1967 to 1971 (Table 3). In the overall river section, there was a reduction of 8 percent. This nonreduction in the upper area was very confusing to me as I expected a decrease. We studied the transects in this area during 1971 at higher waterflows than found in 1962 and 1967, and this could be a major reason in no decrease. The 1972 information should clearup this area of concern or give further proof that we did not get the expected decline. This information will appear in Progress Report III. The upper and lower Stolle monitoring stations (run annually) (Figure 2) showed improvement which conflicted with the river transects (run in 1967, 1971, and 1973) (Table 4). Hopefully, this will be resolved. Boulder steadily increased, while rubble dropped in 1967 and increased again in 1971. Gravels continued to decrease. This decrease in gravel and increase in rubble was easy to see ocularly, but the increase in boulder was not picked up in the ocular examinations. Pool, riffle, and streambanks remained about the same (Table 5). Streambank cover did increase as sedimented areas became vegetated.

Table 2. A comparison of streambed surface materials in the upper 25 miles* of the S.F.S.R., as determined from aquatic environment surveys in 1962, 1967, and 1971.

	MATERIAL-PERCENT				
Year	Boulder	Rubble	Gravel	Fines	Other**
1962	19	40	29	12	0
1967	24	22	26	23	5
1971	33	40	14	24	0

* Includes Upper South Fork, Stolle Meadows and Knox study areas.

** The classification of "other" materials was not used in 1971 or 1962. The substrate under these other materials was used so all material fell in the defined categories.

Table 3 A summary of aquatic habitat survey data for the S.F.S.R. for 1967 and 1971.

Area	Year	Stream			Pool		Streambed surface Composition					Banks		
		Width (ft)	Depth (in)	Riffle (ft)	Width (ft)	Rating	Boulder	Rubble	Gravel (Percent)	Fines	Other	Cover	Condition	Type
Upper S.F.S.R.	1967	19	7	16	3	4	44	22	11	10	13	1.5	1.9	1.7
	1971	18	11	10	8	4	33	29	18	20	0	1.8	1.4	1.4
Stolle	1967	33	14	17	16	3	1	17	49	32	1	0.9	1.3	1.2
	1971	39	14	24	15	3	4	49	15	32	0	1.7	1.0	1.0
Knox	1967	59	17	40	19	3	26	27	19	28	0	1.0	1.2	1.4
	1971	53	18	34	19	3	30	43	8	19	0	1.5	1.5	1.3
Poverty	1967	84	17	52	32	3	21	17	17	45	0	0.9	0.9	1.3
	1971	72	23	36	36	3	33	24	16	27	0	1.6	1.2	1.3
Oxbow	1967	85	19	68	17	3	26	22	10	42	0	0.8	0.9	1.0
	1971	77	20	63	14	4	36	28	13	23	0	1.5	1.0	1.4
Krassel	1967	94	29	75	19	3	36	13	18	33	0	0.9	1.1	1.4
	1971	102	22	63	39	3	29	25	22	24	0	1.0	1.4	1.4
Secesh	1967	110	39	59	51	2	73	19	1	8	0	0.7	1.8	2.0
	1971	120	40	72	48	3	71	20	2	7	0	0.9	1.8	1.8
Mackay Bar	1967	111	39	68	43	2	59	28	6	7	0	0.6	2.0	2.0
	1971	114	32	77	37	3	78	14	2	6	0	1.0	1.7	1.9
Drainage Averages														
	1967	74	23	49	25	3	36	21	16	26	2	0.9	1.4	1.5
	1971	77	24	49	28	3	42	29	11	18	0	1.3	1.4	1.5

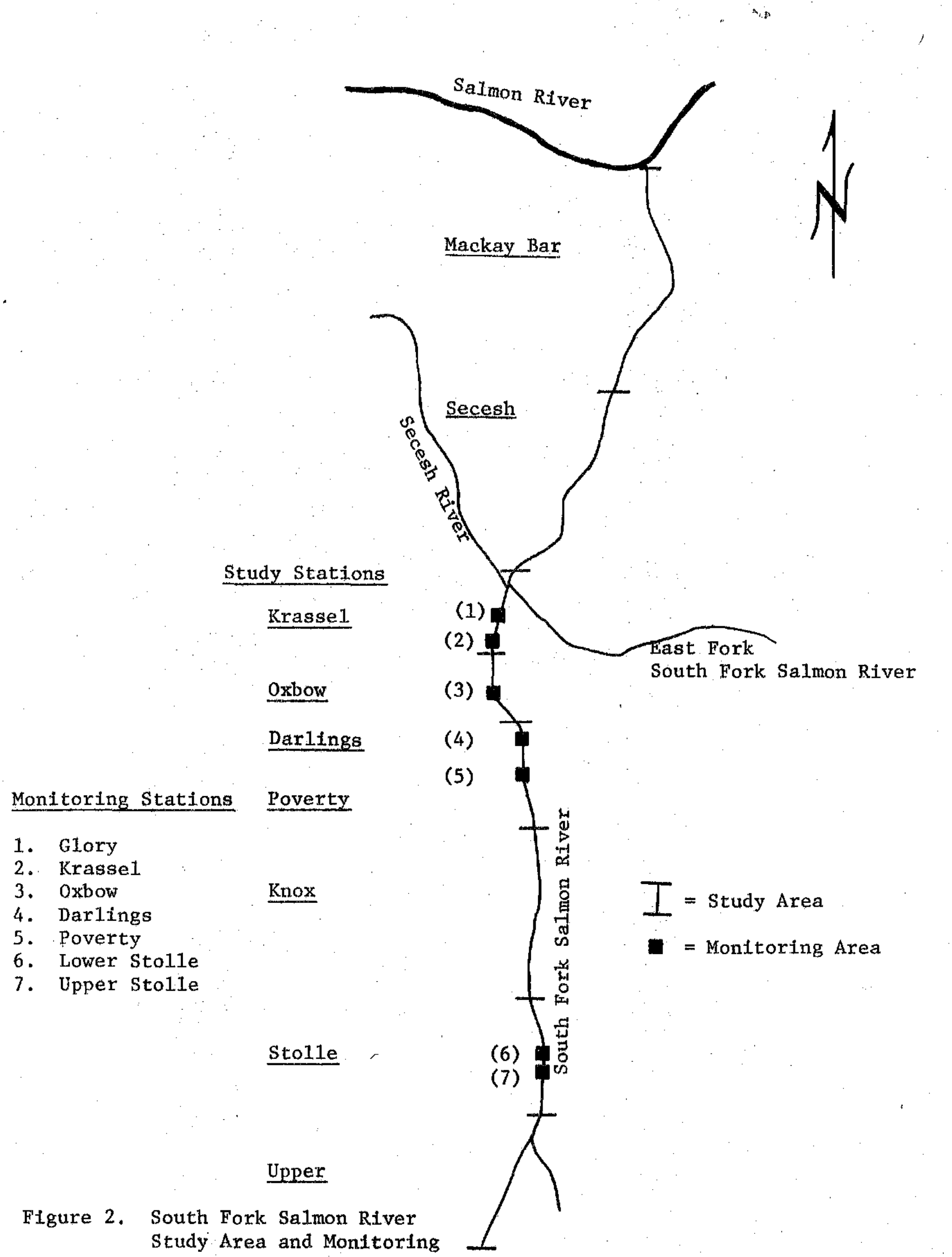


Figure 2. South Fork Salmon River Study Area and Monitoring Station Locations.

Table 4 A summary of aquatic environment physical data from monitoring stations on the S.F.S.R. from 1966 to 1971.

Average Streambed Surface Composition

Year	Boulder	Rubble	Gravel	Fines	Other
1971	3	21	58	18	0
1970	2	8	57	33	0
1969	-	-	-	-	-
1968	3	19	48	30	0
1967	3	17	41	39	0
1966	8	7	39	45	1
1965					
1964					
1963					
1962*	19	40	29	12	0

*Upper 25 stations on the S.F.S.R.

Table 5 Comparison of aquatic habitat conditions in the upper 25 miles* of the S.F.S.R., as determined from surveys in 1962, 1967 and 1971.

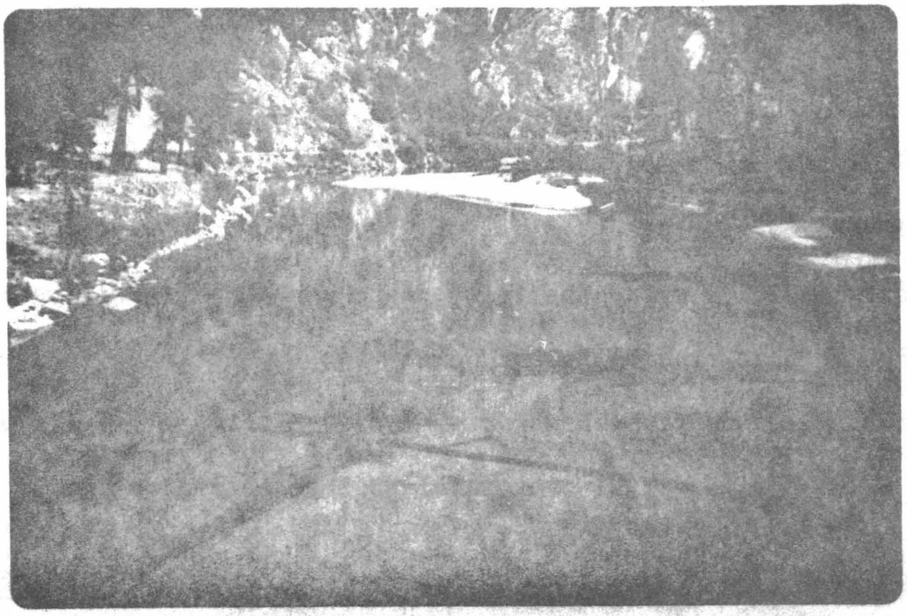
	Stream				Streambank		
	Pool (%)	Rating	Riffle (%)	Depth (in)	Cover	Condition	Type
1962	40	-	60	13.9	1.1	1.6	-
1967	34	3.3	66	12.7	1.1	1.4	1.5
1971	39	3.2	61	14.3	1.7	1.3	1.2

* Includes Upper South Fork, Stolle Meadows and Knox study areas.

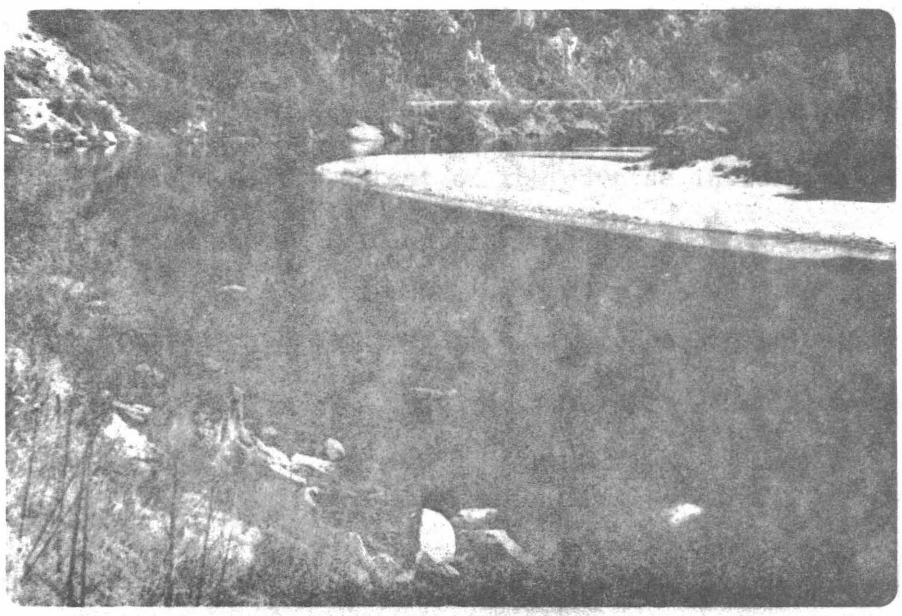
In personal conversation with Mr. George Fritzer, who has lived by the lower SFSR for the past 50 years, Mr. Fritzer stated that sediment deposits did not build up in the river below its confluence with the Secesh River until 1953, and that large sediment deposits did not show until 1965. During the period between 1925 and 1952, the lower half of the SFSR did not show signs of sedimentation.

In 1949, a R4-INT inspection was made in the SFSR drainage from the confluence with the East Fork South Fork Salmon River downstream to Bear Creek (Croft, 1950). During this inspection, no sediment or even small pockets of sediment could be found in the SFSR stream channel from the confluence with Bear Creek upstream to the confluence with Sheep Creek. The only fines found during this inspection were near the confluence of the East Fork South Fork Salmon River (Figure 1).

On September 15, 1965, Krassel District Ranger Ed Heikkenen and Branch Chief James M. Hockaday (USFS) inspected (GII) the same river area and found considerable deposits of fines throughout the streambed (Hockaday, 1965). Storms of October 1962, December 1964, and April 1965, which fell on lands disturbed mainly by logging activities, caused mass erosion resulting in large amounts of fines to be deposited in the river proper, and added greatly to an already existing problem. These long duration storms (1-14 days) produced 2 to 5 inches or more of precipitation and were a very critical factor to sediment accruement when they occurred over a melting snowpack. I have observed the river repeatedly from 1963 through 1971



Photograph 3 - Lower section of Krassel pool in 1967. Sediments are being contained year-round. Pool has lost its depth and conditions favorable for salmonids.



Photograph 4 - Lower section of Krassel pool in 1972. The pool is again starting to form on a year-round basis.

and could see the large annual increases of fines in the SFSR from 1963 through 1965. In the fall of 1964 at a Forest Service-Industry sponsored meeting in McCall, Idaho, I gave a presentation predicting the river would become very badly degraded. This prediction came true in 1965. From 1965 through 1971, I could see these same accrued fines being moved out of the system and the collected data (discussed later) backed these observations.

OBJECTIVES

To meet the objectives of the SFSR environmental studies, the study area included the river from the headwaters to its mouth. The main objectives of the study are as follows:

1. To document the present environmental conditions and determine spatial and temporal changes.

2. To determine the extent of the adverse influences that degraded the aquatic environment.

3. To obtain needed information for recommending methods to be used to restore and maintain favorable aquatic environment conditions.

METHODS

The methods, techniques, and equipment used to conduct this study are thoroughly described in Appendix I.

AQUATIC ENVIRONMENT

Sediment Types

Much of the SFSR sediment accruement is due to landslides and slumps which are generally associated with intensive storms, coupled with disturbed lands (Jensen, 1965). Road construction, mining, logging, fire, and domestic livestock have all contributed to the accelerated sediment loads the river has received. Most of the accelerated sediment received by the river was from roads constructed for logging purposes.

The parent material of the watershed, especially in the decomposed granite lands, readily disintegrate into coarse granular materials (Jensen, 1966). Much of the bedrock material is composed of quartz monzonite which is dominantly coarse to medium grained. Bedrock, or parent materials of this type, result in coarse granular sediment. Jensen reported the average composition of the soils as 80 percent sand and gravel, 10 to 15 percent silt, 5 to 10 percent clay, and 2 to 5 percent organic material. This explains why the major portion of the soils delivered to the SFSR and its tributaries become bedload materials.

Bedload material is that portion of the total sediment load whose immersed weight is carried predominantly by the solid bed and because of particle size and weight does not readily flush out the stream (Bagnold, 1956). Bedload fines, for this study, are classified as sediment between .20 mm. and 4.7 mm. in diameter (Table 6). This bedload material, because of its predominance and characteristics, is the major factor responsible for reducing the value of SFSR aquatic habitat.

Table 6 Gradation classification used in evaluating the streambed surface and depth materials composition.

INCHES		MILLIMETERS	
12 AND OVER		304.8	BOULDER
11		279.4	
10		254.0	
9		228.6	
8		203.2	
7		177.8	RUBBLE
6		152.4	
5		127.0	
4		101.6	
3		76.1	
2.99		76.0	
2		50.8	
1.50		37.6	
1		25.4	
.75		19.0	
.50		12.7	GRAVEL
.375		9.51	
.187	Fine Gravel	4.76	
.079	Coarse Sand	2.00 to 4.75	
.033		.833	
.016		.420	
.010	Fine Sand	.250	FINES
.004		.105	
.003		.074	
50 Micron		.050	
5 Micron	Silt	.005	
2 Micron		.002	

The suspended sediment load (that part whose immersed weight is carried by the fluid and this finally by the interstitial fluid between bed grains) makes up a minor portion of the total sediment load. The suspended sediment load during most riverflows is low, averaging 54 p.p.m. total residue (Platts, 1968), and has very little effect on the river environment or the fishery resource.

Sediment Influences

Fines, when blanketing over and infiltrating into the spawning materials, can cause serious mortalities among salmonid embryos, alevins, and fry still in the gravel. The fines blanketing the spawning areas and penetrating the interspaces kill the alevins by shutting off oxygen, concentration of metabolic wastes, or not allowing them to emerge to surface waters. Fines have a decreasing effect on the rate of permeability and water interchange through spawning gravels and food rearing areas (Cooper, 1959; Cordone, 1961).

The potential of a salmonid spawning bed to produce fry is directly related to its permeability (Vasil'en, 1964). The relationship between the coefficient of permeability and the fraction of the bottom materials containing fines is inverse.

Fines also reduce the available food supply, the degree of reduction depends on the amount and type of sedimentation. Shifting fines create unstable conditions, and organisms inhabiting the streambottom

are particularly vulnerable to decimation by increased waterflows. The unstable fine layer forms a false streambottom that is very poor in supporting benthic organisms. With the decimation or elimination of benthic organisms, the food chain is disrupted and upper trophic levels must decrease also.

Fines in the SFSR during 1964-1969 filled many of the pools, which in turn decreases the feeding, resting, escape, and overwintering areas of salmonids and this reduces carrying capacity. Since 1970, pools have been gaining depth and taking on the morphometric conditions of the past before degradation. The comeback can be seen very dramatically in the Swimming, Krassel, and Glory pools (Photographs 3, 4, 7, and 8).

Shaw (1943) found that the greatest damage to spawning areas occurred when sediment drift occurred during low water conditions when water velocities were insufficient to keep the sediment moving. This was a major problem in the SFSR from 1965 through 1970 because sediment was moving downstream the year-round. In 1971, for the first time prior to 1965, the SFSR was capable of containing the majority of its fines during low flows.

A stream located within a good watershed with low sediment accruement develops a sediment containment factor that results in no significant bedload sediment movement during low waterflows. The natural sediment containment structures (pools, rocks, logs, plants, and debris) within

a well-conditioned watershed and stream will stop and contain normal amounts of downstream-moving bedload sediment that are accrued from streambanks, surrounding areas, or dislodged from the streambottom. The author found this to be true even in heavily sedimented streams such as Bear Valley Creek. Sampling with Arnhem bedload samplers in this stream failed to pick up fines 8 miles below the large fine sources lodged in the streambed.

Sediment Conditions (1962-1967)

As stated in methods, techniques, and equipment (Appendix I) the river was stratified into eight study areas (Figure 2). Aquatic habitat documentation, analysis, and evaluation were obtained by analyzing data from 335 randomly located study transects (1967 and 1971), and 70 additional stream transects read annually in spawning areas. Two hundred and thirty-five randomly collected streambed depth material samples were collected during 1967 and about 60 core samples have been taken annually from the spawning areas since then.

Whitt (1962) stated in the 1962 aquatic environmental survey of the upper SFSR drainage that, "The SFSR and its tributaries (from the headwaters to the Payette-Boise boundary) were in very good condition as related to habitat." Comparing the 1962 and 1967 aquatic environment physical surveys, sediment containment in the river from the Boise-Payette boundary to the headwaters had doubled. Based on my qualitative information and ocular inspection, this sediment change has also occurred in the majority of the river. From 1965 to 1971 there was a definite move made by the river toward natural conditions.

Sediment Conditions (1967-1971)

From 1968 through 1971, contained fines decreased steadily at a rate of 4.2 percent per year in the spawning areas (Figure 3). All areas of the river did not decrease at the same rate. The upper and Stolle River areas had no decrease based on 1967 and 1971 data. We inventoried the 1971 upper and Stolle transects prior to low streamflows and this may have biased the results. The sides of stream channels tend to contain more fines than midchannel. This could increase fine content over those done on base flow levels. The 1972 analysis (conducted during low flows) should determine if this higher flow work biased the results. This will appear in Progress Report III.

Spatial and temporal conditions and changes and amounts of contained fines were found between the different study areas (Table 7). From 1967 to 1971, the Stolle study area remained the same in fines contained and the upper study area showed an increase. The big temporal decreases in stream channel fines were in the Knox, Poverty, Oxbow, and Krassel study areas, amounting to a 17 percent average. The bulk of the spawning takes place in these areas. There was a small decrease in fines in the Secesh and Mackay Bar study areas (Figure 4). These two areas, because of high stream bedload movement capacity naturally have a low amount of contained fines. Gravel also decreased significantly in the Stolle, Knox, and Mackay Bar areas. Boulder increased in the Stolle and Mackay Bar areas.

Figure 3 Percent surface fines by year for the monitoring stations on the S.F.S.R.

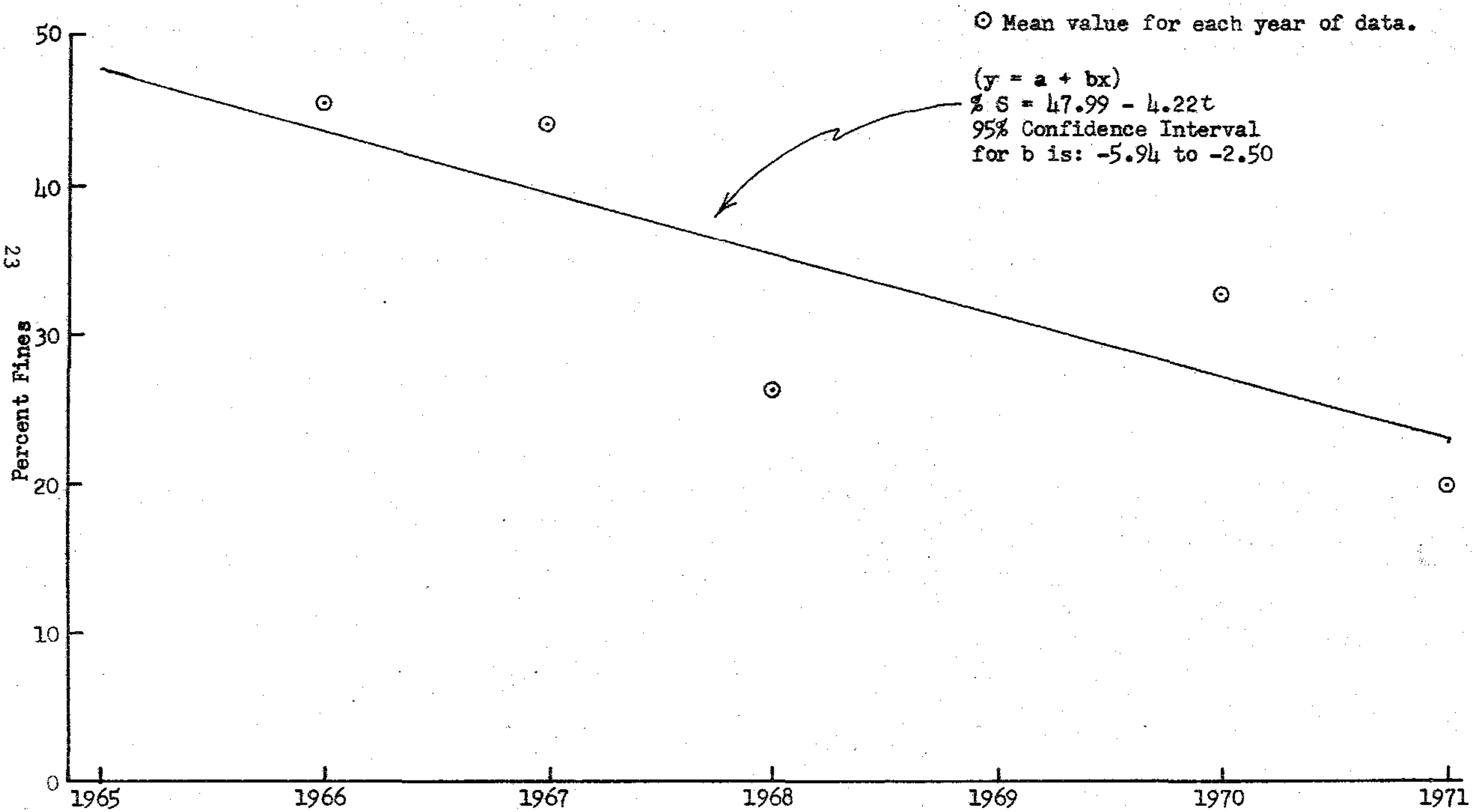
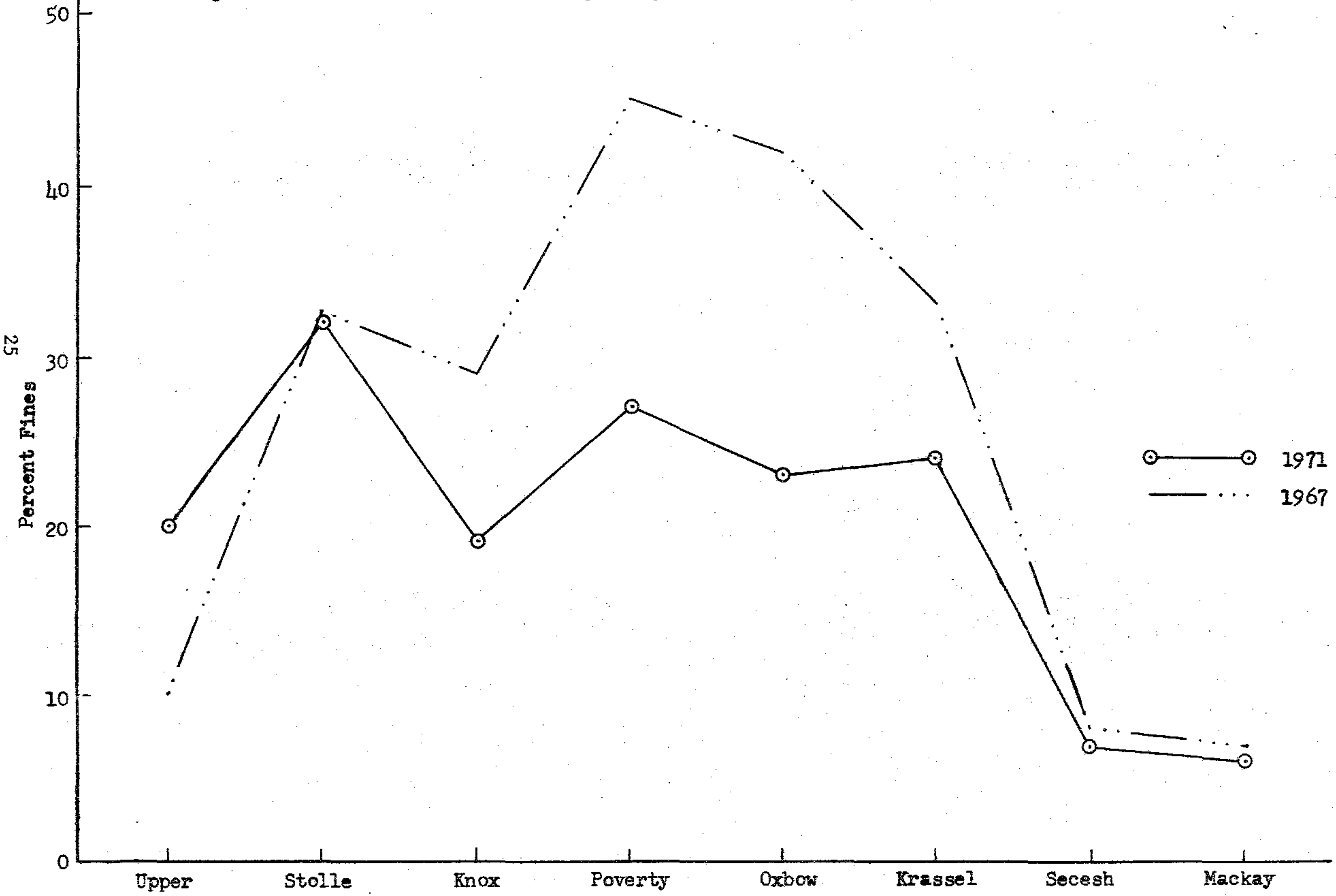


Table 7. Significant differences in means for streambed surface material classes indicated by an increase or decrease in percent for each study area from 1967 to 1971.

	Study Areas							
	Upper	Stolle	Knox	Poverty	Oxbow	Krassel	Secesh	Mackay
Fines	Incr. (80-90)*	approx. same	dec. (90-95)	dec. (95. 97.5)	dec. (80-90)	dec. (50-60)	dec. (<50)	(<50)
Gravel		dec.	dec.					dec.
Rubble		incr.	incr.			incr.		dec.
Boulder		incr.						incr.

*Confidence levels

Figure 4 Percent surface fines by study station for 1967 and 1971 S.F.S.R.



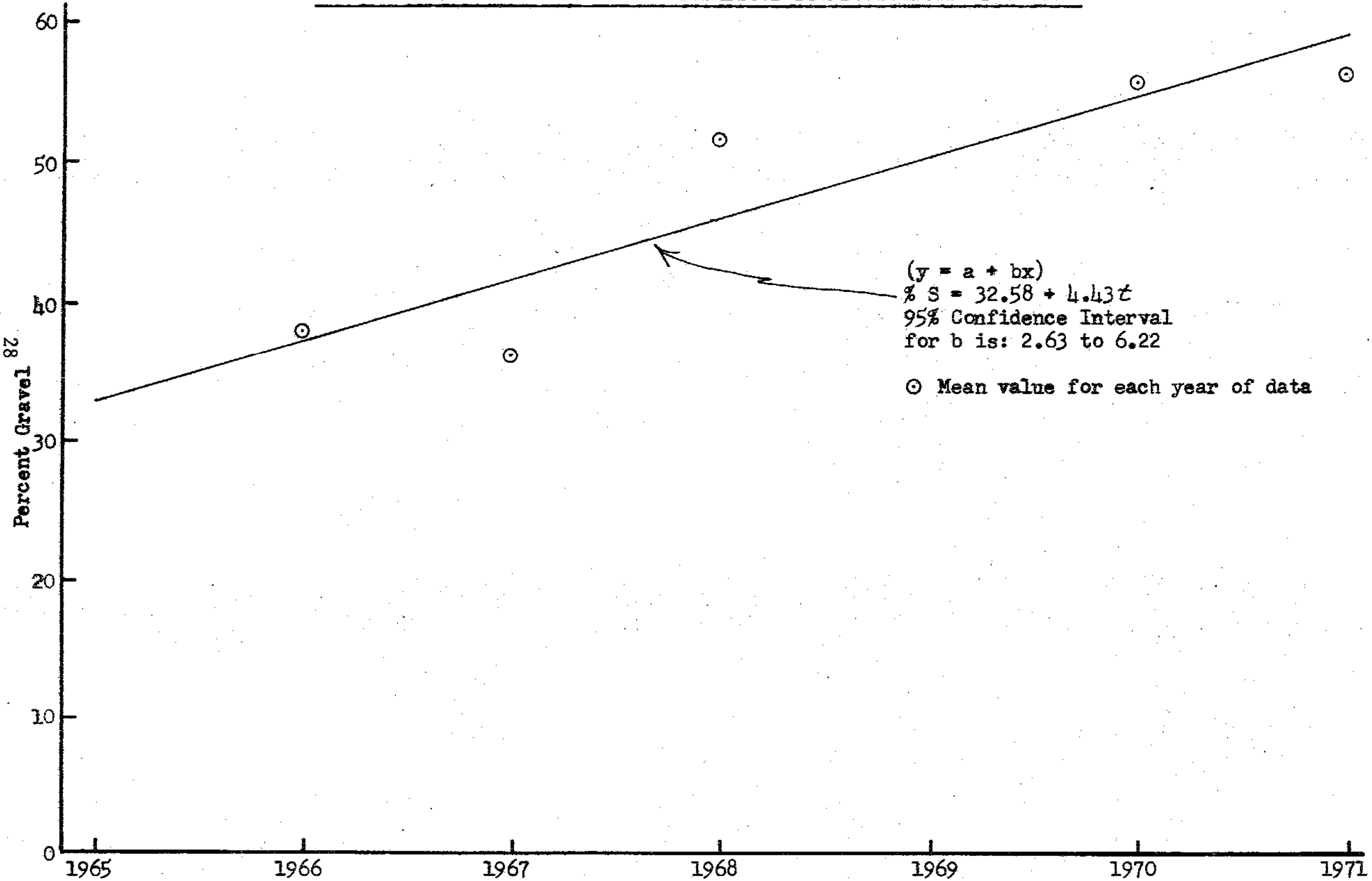
From 1967 to 1971, there was practically no difference in the river's average width (74 feet to 77 feet), average depth (23 inches to 24 inches), average riffle (49 feet to 49 feet), pool width (25 feet to 28 feet), pool rating (3 units to 3 units), bank condition (1.4 units to 1.4 units), and bank type (1.5 units to 1.5 units) (Table 3). There were changes in streambottom materials composition with boulder (36 percent to 42 percent) and rubble (21 percent to 29 percent) increasing from 1967 to 1971. This would be expected in a stream scouring its channel (armor plating) and exposing larger size sediments more resistant to the friction of the flowing water. Gravel decreased (16 percent to 11 percent) and fines also decreased (26 percent to 18 percent) from 1961 to 1971. Bank cover gained from 1967 to 1971 in cover condition (0.9 units to 1.3 units). This would be expected as the many large sediment deposits lying exposed during 1967 started to support a grass-forb vegetative type in 1971. Willow was also increasing in those areas covered in the 1965 sediment deposits and disturbed areas (Photographs 1, 2, 3, and 4).

From 1966 through 1971, certain monitoring stations were studied each year to determine the status of the river and any temporal changes that may develop. The information collected demonstrated that the river was moving steadily toward natural conditions that existed prior to logging activity within the watershed. The stream was moving toward an equilibrium condition as the watershed decreased its stress on the system.

In 1965, surface fines made up about 50 percent of all the materials in the spawning areas. From 1965 to 1971, there was a fairly steady decline in fines of 4.2 percent per year. Although the long term decline is probably curvilinear, such a trend is not supported by the limited data to date. It was calculated as linear with the equation being fine substrate percent = 47.99 - 4.22 t. The amount of decrease in surface fines was significant at the 95 percent confidence interval. By 1971, surface fines had decreased to 25 percent (in salmon spawning areas) of the streambottom materials, for a 50 percent reduction (Figure 3).

Surface gravels in the monitoring areas also increased from 1965 to 1971. Note that they decreased in the overall river comparisons between 1967-1971. Spawning salmon and steelhead utilize those areas of the river that have low gradient and therefore these areas become natural gravel traps. Most of the river channel has such high competency that gravels are not allowed to remain in the streambed. During 1965, surface gravel in the spawning areas made up only 30 percent of the streambottom materials. Gravels increased at a rate of 4.4 percent annually and during 1971 made up over 50 percent of the spawning area streambottom materials. The linear equation was gravel substrate percent = 32.58 + 4.43 t, and was significant at the 95 percent confidence interval (Figure 5). Surface rubble in the monitoring areas appeared to increase from 1965 to 1971. During 1965,

Figure 5 Percent surface gravel for the monitoring stations on the S.F.S.R.



the salmon spawning areas were composed of about 12 percent rubble, increasing to 16 percent in 1971. The linear equation was rubble substrate percent = 13.21 + 0.55 t; however, it was not a significant increase at the 95 percent confidence interval (Figure 6).

Surface boulder appeared to decline during the period and I have no explanation for this other than boulder could have been covered with gravel. Salmon spawning areas naturally contain very little boulder material because they are found only in alluvial types. Boulder made up about 6 percent of the total materials in 1965 and only about 2 percent in 1971. The equation was boulder substrate percent = 6.33 - 0.75 t (Figure 7).

From 1967 through 1971, the decrease of some materials and increase of others closely fit linear representation. However, it is expected to change to curvilinear representation as the river approaches natural conditions. The lines representing the percentages of the different streambottom materials should start curving toward natural conditions as the river approaches prelogging state. This approach to natural conditions will only occur if the stress from the surroundings (watershed) is constantly being lessened. Large floods, major natural events, or additional disturbed lands from new logging operations could reverse these trends.

Figure 6 Percent surface rubble for the monitoring stations on the S.F.S.R.

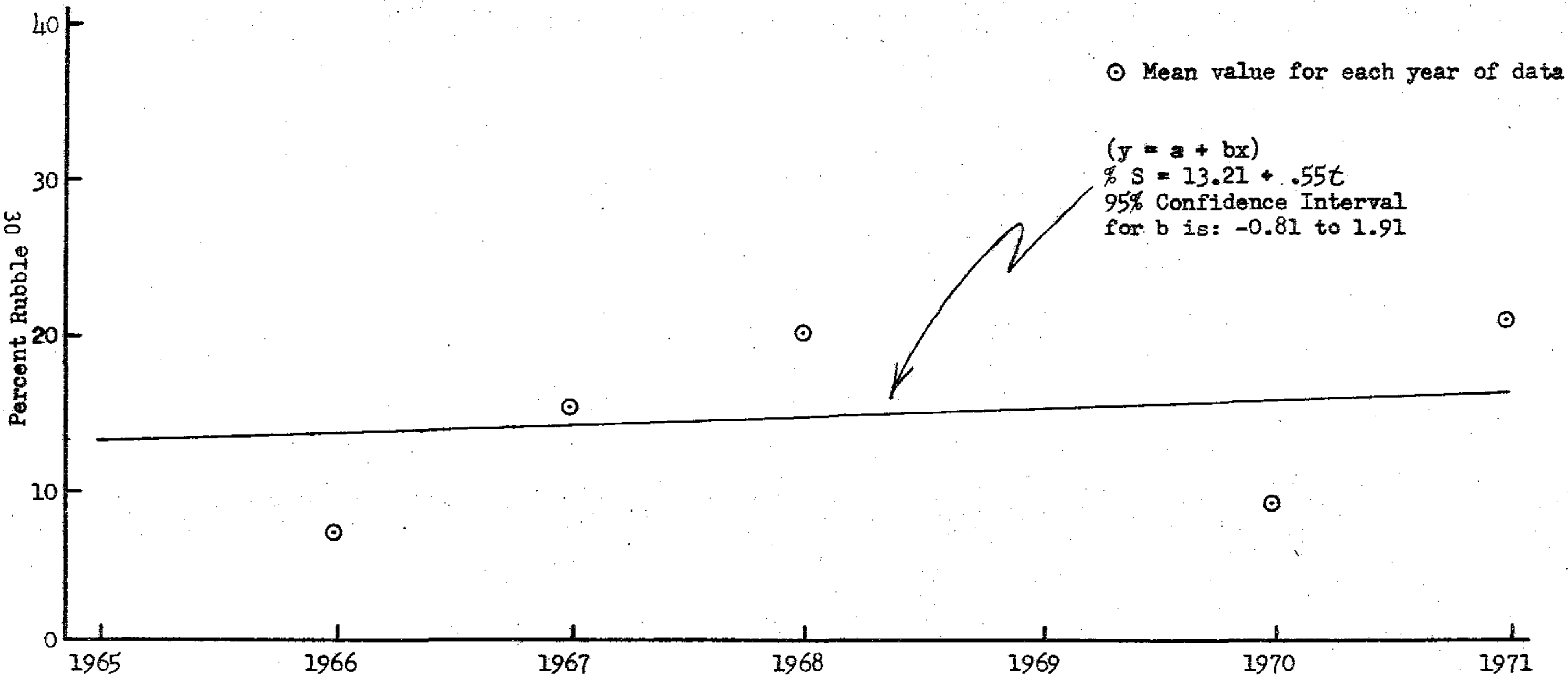
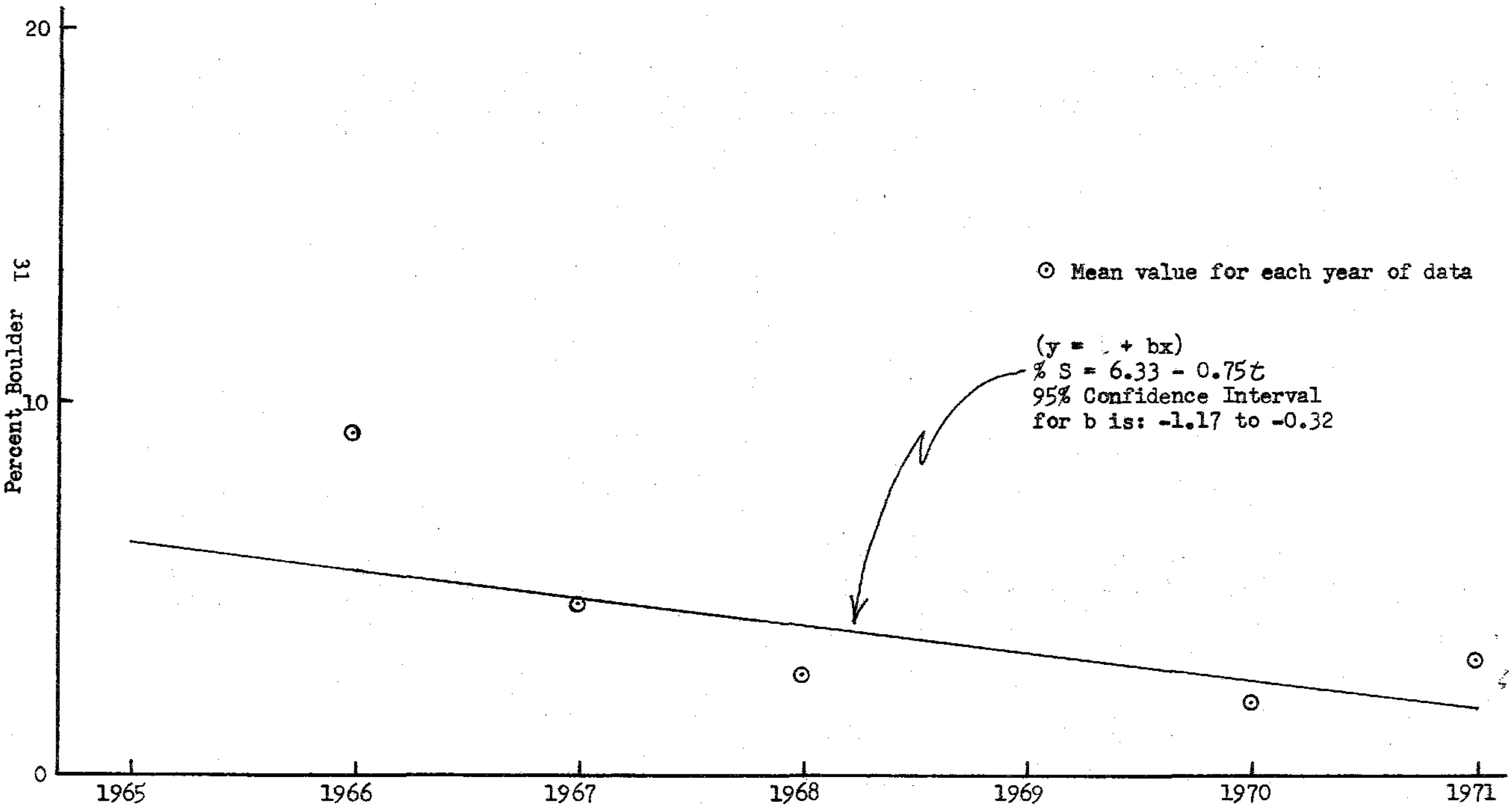


Figure 7 Percent surface boulder for the monitoring stations on the S.F.S.R.

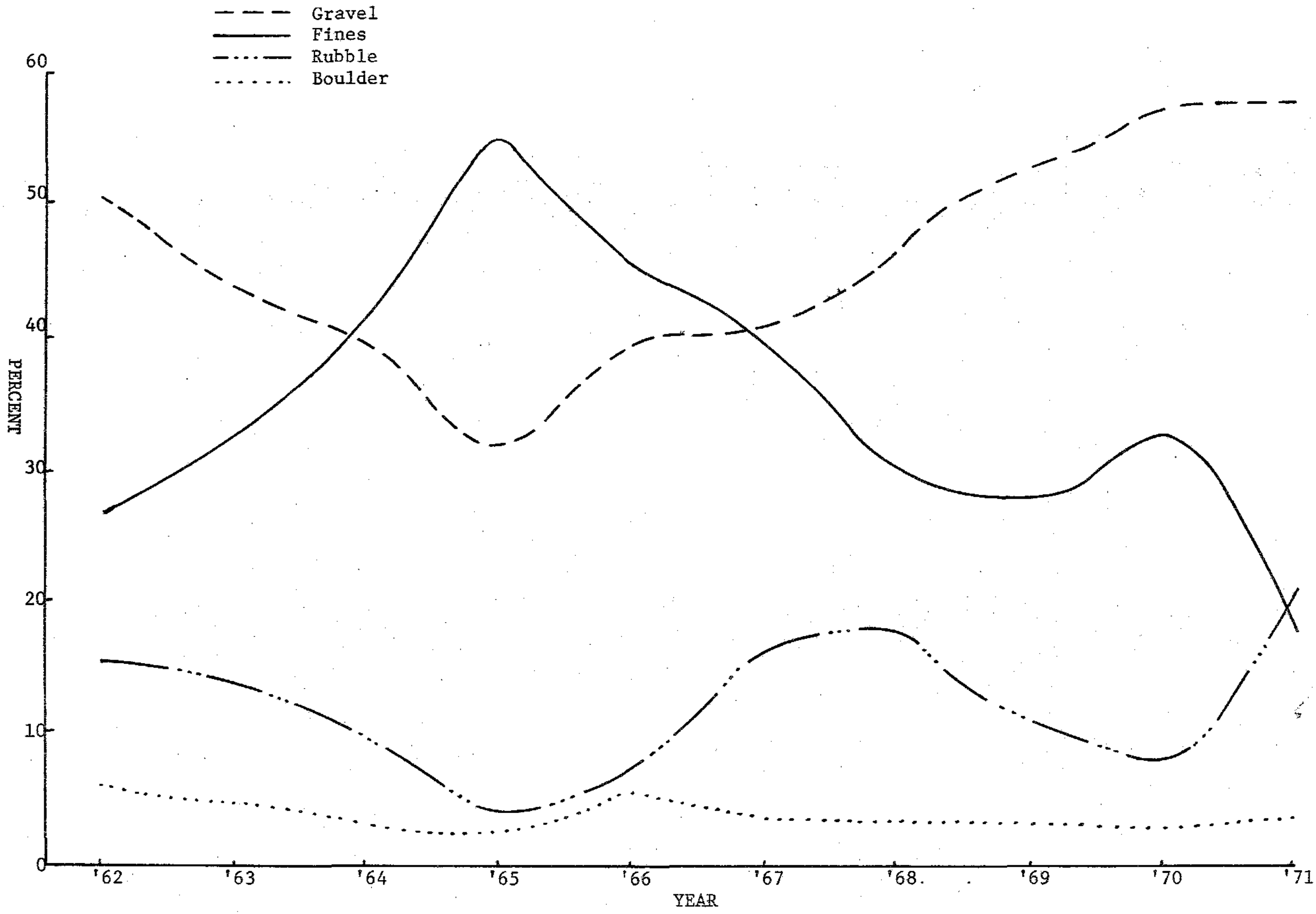


My thinking on what happened during years prior to 1967 when no data was available except for some upriver work in 1962 is reflected in Figure 8. I was conducting salmon spawning studies in the early 1960's and could see the annual increase in fines. By 1962 the river had accumulated too many fines for good spawning conditions. The linear representation indicates that fines made up about 50 percent (spawning areas) of the materials in 1965. Based on comparable conditions in 1968 (river now decreasing in fines) with 1962 it is estimated that spawning areas contained about 30 percent surface fines in 1962. Percentage of gravel was probably less than it is now. I feel gravels in the spawning areas will decrease (also in the overall system) in future years to a lower level which would represent natural conditions.

It must be considered that the reason the SFSR is such an ideal salmon and steelhead stream is that the river has difficulty in eliminating the incoming sand and gravel, yet it quickly eliminates silt and clay. By being able to contain gravel along with boulders and rubble, it supplies the necessary requirements for both spawning and rearing.

From 1965 to 1971, land uses within the drainage (mainly logging and road construction) were curtailed, thus relieving input of sediment. As this stress was relieved and climatic conditions worked in favor of the system, the aquatic environment started moving toward favorable conditions. The environment, as demonstrated by both the monitor stations

Figure 8 Percent sediment materials composition in streambed (surface) monitoring stations in the SFSR.



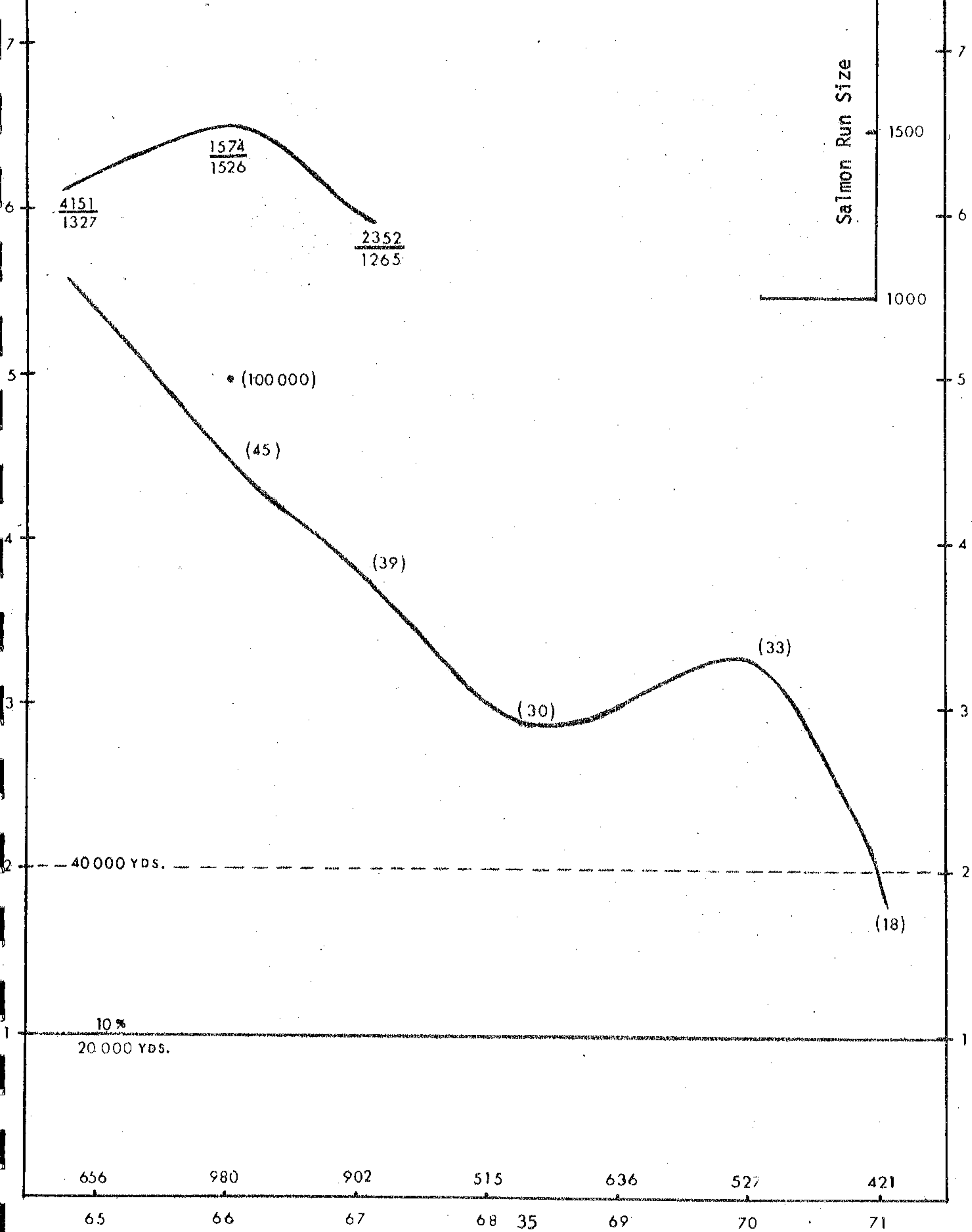
33

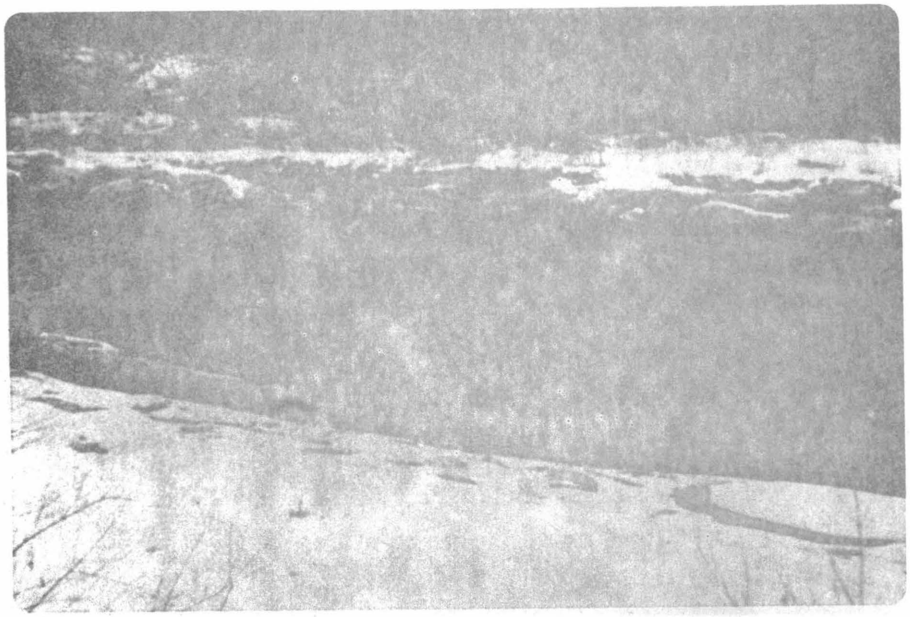
and study stations (randomly picked), has made a definite comeback, but still needs improvement to gain near-natural conditions. If the downward curve continues the system is only a few years from gaining near-natural conditions, providing new land uses and existing uses (mainly roads) do not impede the decline of the curve. The river has demonstrated it is very capable of gaining and keeping favorable conditions when stresses are relieved and is capable of continuing to do so under normal storm patterns as long as the watershed is in near-natural conditions.

Spawning areas have improved and the pools are gaining their past depths. The food producing areas are gaining better site classification and thus contribute more to the food chain, and better cover is appearing in the rearing areas. The lower segment of the system is showing relief from the past abrasive effects. The salmonid populations held in check by these conditions should show signs of improvement.

The magnitude of the fines as compared to assumed natural conditions is shown in Figure 9. From previous work on the SFSR and other studies, it is assumed the system naturally had about 10 percent fines. Based on this, the system within the spawning areas has moved from a five times pollution factor. There is still twice as much fine material contained within the system as there should be. Thus, the river still has to continue to eliminate more fines than being accrued from the surroundings.

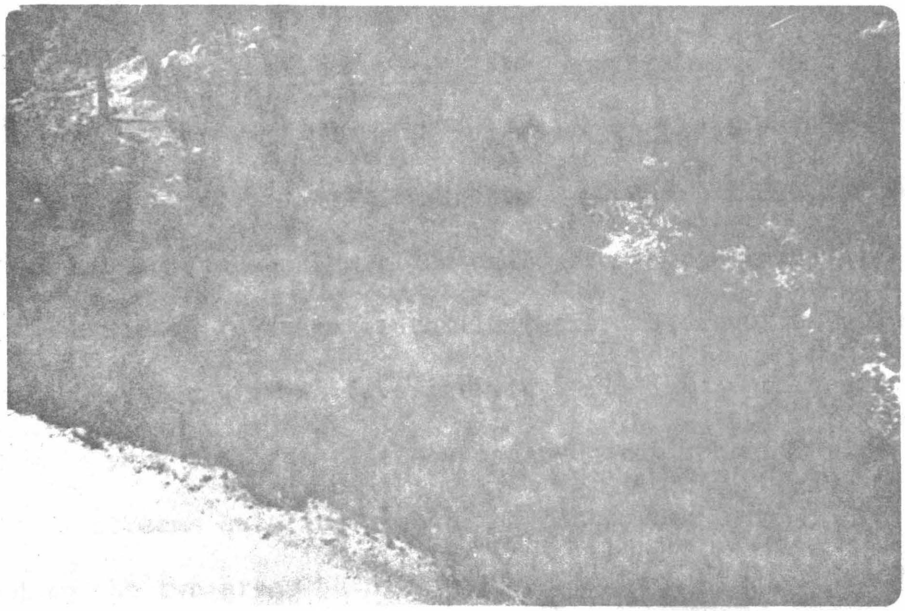
Figure 9 Magnitude of surface streambed fines in the South Fork Salmon River monitor stations.



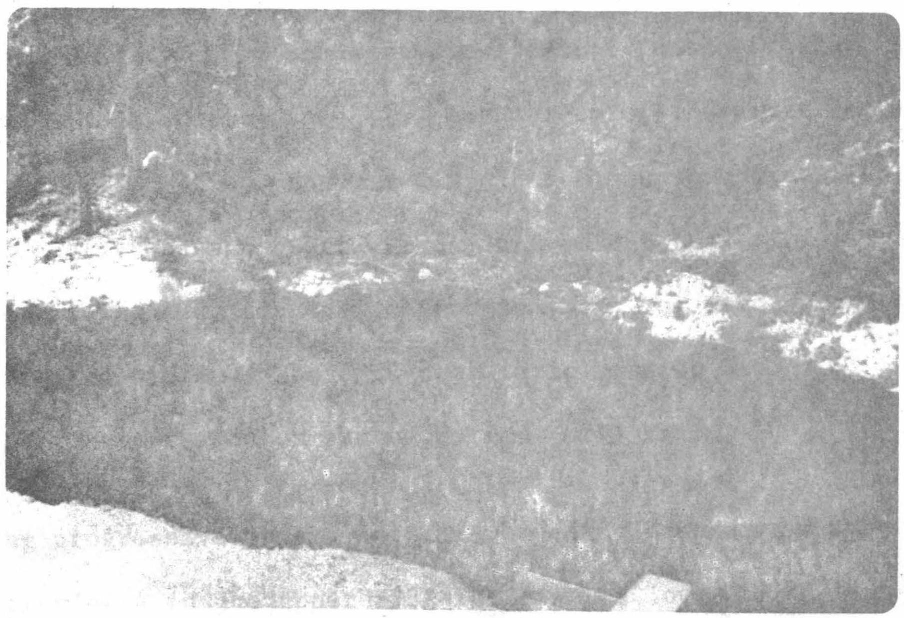


Photograph 5 - Poverty spawning area in 1966. Fines are so dominant that their depth causes ripples and dunes.

Photograph 6 - Poverty spawning area in 1972. Fines have been largely eliminated and gravels are dominant.



Photograph 7 - Swimming hole (pool) in 1966, almost totally filled in with fines.



Photograph 8 - Swimming hole (pool) in 1972. Fines are being moved through the pool and it is taking on morphological conditions of predisturbed charactertistics.

Width, Depth, and Pool - Riffle Conditions

As expected in most streams, the SFSR increases in the upper half in depth and width as it progresses downstream. However, there was very little difference in the average width and depth in the lower half of the river. The Secesh (average width 110 feet, and depth 39 inches) and the Mackay Bar Study areas (average width 111 feet, and depth 39 inches) were very similar. The steep canyon environment, plus very few large streams entering within the Mackay Bar area, contributed to the two areas being similar. In both studies (1967 and 1971) of these two areas, water discharge rates were very similar as the study areas were surveyed on the same month of each year.

The pool-riffle ratio throughout the drainage is classified as poor (based on the ratings from other studies) except in the Stolle Meadows and Secesh areas (Table 8). Most areas of the river naturally have a low pool-riffle ratio. Heavy sedimentation, in some areas, has eliminated pool areas and depth which would affect pool-riffle ratio. Pools were gaining a better environment in 1971, but it did not show up on the rating system. The SFSR pool ratio of 1 to 2 is 100 percent lower than the often stated optimum of 1 to 1.

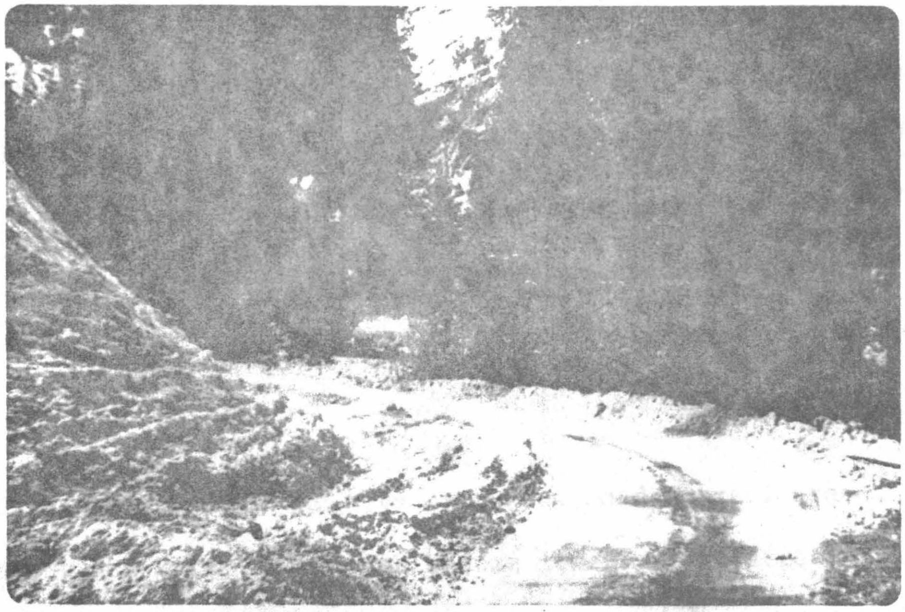
Pool rating progressively gets better proceeding down drainage, dropping from a rating of 4 in the upper SFSR to 2 in the lower SFSR. The upper SFSR study area comprises a small stream, steep gradient, and shallow water depths which naturally tend to cause poor pool environments.

Table 8 Average pool-riffle ratio for the SFSR by study area for 1967 and 1971

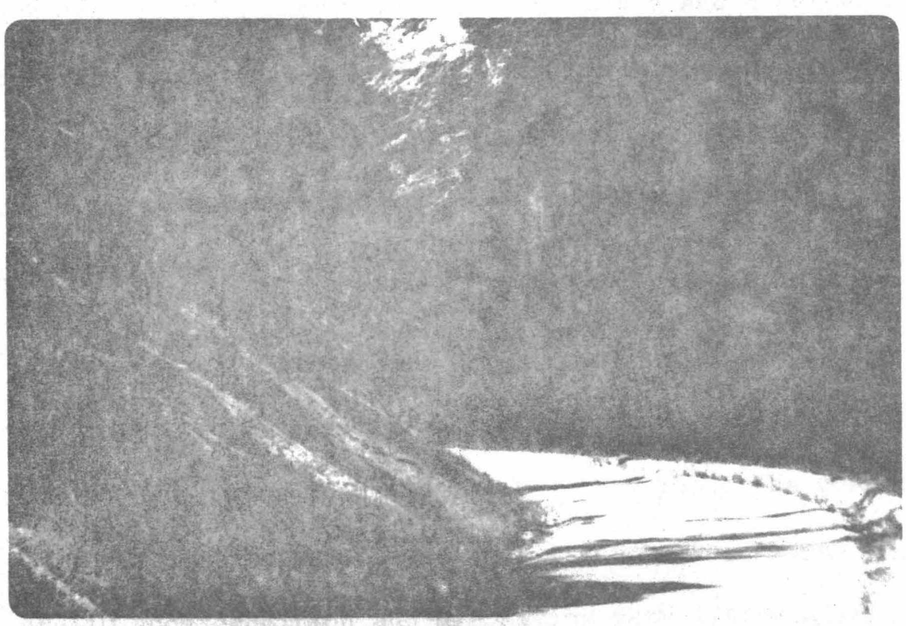
	Year	Width	Percent	Width	Percent	Ratio
Upper SFSR	1967	3	15	16	85	1:5.3
	1971	8	44	10	56	1:1.2
Stolle	1967	16	48	17	52	1:1.1
	1971	15	38	24	62	1:1.6
Knox	1967	19	32	40	68	1:2.1
	1971	19	36	34	64	1:1.8
Poverty	1967	32	38	52	62	1:1.6
	1971	36	50	36	50	1:1.0
Oxbow	1967	17	20	68	80	1:4.0
	1971	14	14	63	82	1:4.5
Krassel	1967	19	20	75	80	1:3.9
	1971	39	38	63	62	1:1.6
Secesh	1967	51	46	59	54	1:1.2
	1971	48	40	72	60	1:1.5
Mackay Bar	1967	43	39	68	61	1:1.5
	1971	37	32	77	68	1:2.1
Average	1967	25	32	49	68	1:2.6
	1971	27	37	47	63	1:1.9

Photograph 9 - Main South Fork Salmon River road in 1967 showing raw areas.

Photograph 10 - Main South Fork Salmon River road in 1972 (same section as photograph 9) showing some improvement in stability.



Photograph 11 - Road to South Fork Plunge in 1967 in raw condition.



Photograph 12 - Road to South Fork Plunge in 1972 showing rehabilitation.

The Stolle Meadows area increased in pool rating to 3. This area has gained in water depth and flows and acquired a lower stream gradient. This, plus stream sinuosity and undercut banks, results in better pool quality. In the Knox area, stream gradient, waterflow and water velocities again increase, but pool ratings remain the same as in the Stolle area.

As the river passes through the Poverty, Oxbow, and Krassel areas, stream gradient and water velocities become lower. This stream section has a potential for a better pool rating, but heavy sedimentation has caused lower pool ratings by eliminating water pool depth and escape cover. This pool rating should become better as pools are being cleaned out by scouring. In the next two downstream study areas (Secesh and Mackay Bar) surface fines drop to only 7 and 8 percent, respectively. The competency to move sediment is high and pool depths are being maintained, resulting in good pool ratings. There are signs of pool deterioration, but this is minor compared to the Poverty and Krassel areas.

Streambanks

The streambank condition ratings are based each year (1967 and 1971) on 670 recorded observations randomly located throughout the complete SFSR. The analysis of this data shows that streambanks, except in a few cases, are in good condition and are having very little adverse effects on the aquatic environment. Sediment deposition in the

streambank-streambed area, however, resulted in streambank cover rated only fair and condition rated as good. The major factor downgrading streambank condition is the constant moving bedload sediment that deposits at the sides of the original banks, especially in low gradient areas. This is especially noticeable in the Stolle Meadows area. Because streambank condition was rated considering the interception of low water with the streambank, sedimentation had some effect on the rating. Without this heavy sedimentation, the SFSR streambanks would be fairly stable and rated higher. An interesting fact is that the stream channel area discharging the heaviest sediment loads (Mackay Bar area) has the best streambank environment. Since 1965, there has been an increase in vegetation on streambanks which enhances stability.

The only major accelerated sediment accruement from streambanks found in the 670 observations each year were those serving as road fills due to road encroachment. Recorded transect observations on streambank road fills tended to lower streambank condition because road fills functioning as streambanks rate very low in cover, condition, and type.

Streambed Depth Materials Composition

Streambed core sampling was undertaken to define the streambed materials composition as to gradation size, spawning bed material

composition, and sediment content and to be able to compare spatial and temporal differences and changes. Spawning bed material composition will be taken up in more detail under "Spawning Conditions."

During the 1967 studies, 155 streambed core samples (6 inches in diameter) were collected randomly in the channel river from the headwaters to the confluence of the Secesh River, plus 80 samples from major spawning areas.

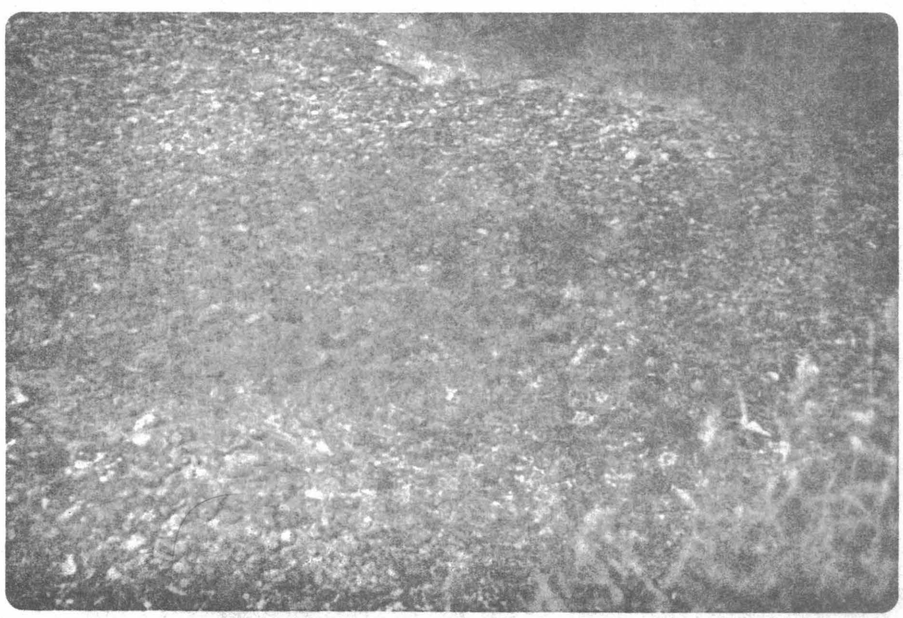
The streambed from the SFSR headwaters to the confluence of the Secesh River contained 32 percent materials between .833 m.m. to 9.5 m.m. Other SFSR streambed depth samples have tended to center within this range showing that the SFSR sediment, due to coarseness of the watershed soils and sorting by the water action, tends to produce a sediment size which in turn results in predominant bedload sediment. In the analysis of the bed material, often it is discussed as two gradation groups: that material that passed the .833 m.m. screen and that material that passed through the 9.5 m.m. screen, but did not pass the .833 m.m. screen.

Thirty-one percent of the particles sampled from the stream transects were trapped or fell through the .833 m.m. screen. This compares with the overall spawning area average of 28 percent and redds average from 18 to 28 percent. Johnson Creek (a salmon spawning stream in the SFSR drainage) spawning areas averaged between 5 and 10 percent. Johnson Creek is probably in near-natural conditions.

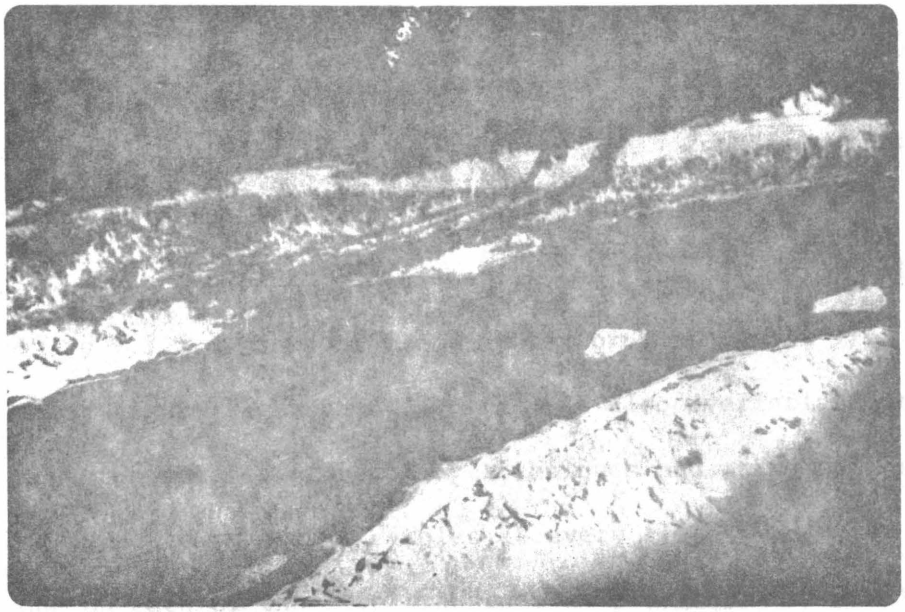
Photograph 13 - River bend above Darling spawning area in 1966. Fines were of sufficient depth to ripple and dune.

Photograph 14 - River bend above Darling spawning area in 1972. Fines were of less depth, but still a potential problem to the spawning area below. More gravels and rubble are showing.

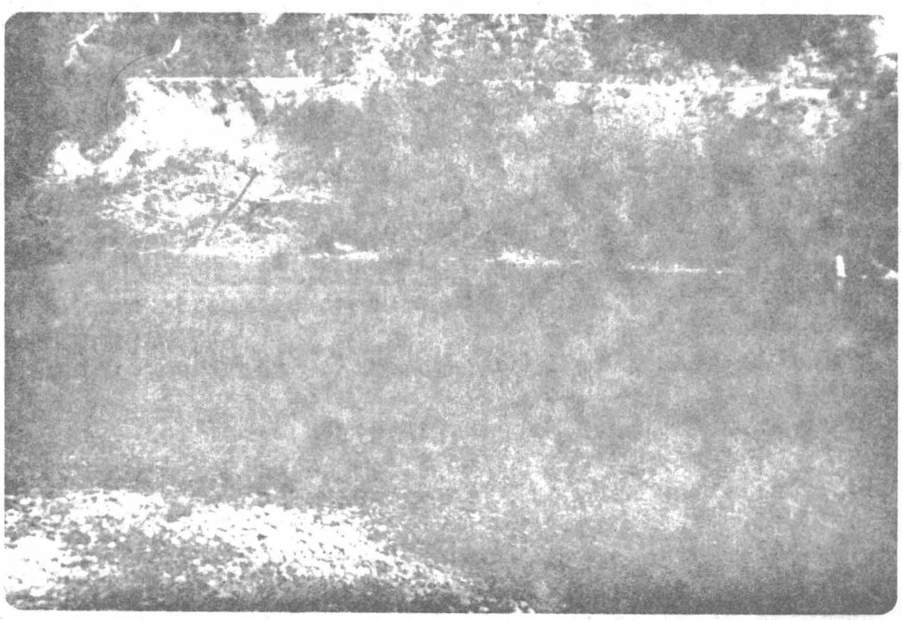
Photograph 15 - Fine buildup in November 1967 over salmon redds in the Poverty spawning area.



Photograph 16 - Condition of redds in the Poverty spawning area in September 1972. Very few fines transported or left on top of redds.



Photograph 17 - Lower Poverty spawning area in January 1965. Fines completely dominate and are rippling.



Photograph 18 - Lower Poverty spawning area in September 1972. Fines on the surface have been mainly eliminated. Gravels are starting to dominate.

In 1967, the SFSR contained more streambed fines than the maximum levels permissible. In 1967, the actual sediment percentage figure would probably be slightly lower than indicated by the 50 core samples which show that 50 percent of the streambed material composition is 9.5 m.m. in particle diameter or less (Table 9). The 31 percent figure (less than 2.0 m.m.) is also overinflated to an unknown degree because of sampling techniques and equipment used. It was programmed to take five samples at every fifth SFSR study station, one on each of the five transects at predetermined points. However, the sample stations did not always fall where the equipment would work. Large material or deep water depths made it necessary on many occasions to find smaller materials or less water depths. This would result in a bias in the results and should be considered in any interpretation of the data.

In 1967, the SFSR streambed depth sediment content (50 percent fines) was higher than streambed surface sediment (33 percent). A stream naturally tends to armorplate its streambed after receiving heavy sedimentation and streambed depth sediment could be higher than streambed surface sediment. Although the 1967 streambed depth sampling results for the study station work should be analyzed with reservations, it is reliable enough data to show definitely that fines contained in the SFSR streambottom are excessive and doing damage to the SFSR aquatic habitat. The comparison of streambed

Table 9 Gradation analysis size in percent of total volume of 50 streambed samples collected randomly from the SFSR from the headwaters to the confluence of Tailholt Creek, September 1967.

	Station Number										
Gradation (m.m.)	5	10	15	20	25	30	35	40	45	50	Average
76.1	80*	2	19	4	7	2	4	25	3	10	16
50.8	2	14	12	2	3	2	7	21	5	15	8
37.6	2	11	7	7	5	2	6	6	8	10	6
25.4	3	5	8	7	6	1	6	9	6	12	6
19.0	2	20	4	7	5	3	3	3	2	7	6
12.7	5	5	3	7	3	2	5	4	2	6	4
9.51	1	2	3	6	8	9	2	3	2	2	4
4.76	3	9	6	8	6	3	10	6	6	6	6
2.00		10	21	16	21	19	14	11	11	5	13
.833	2	5	12	9	10	28	17	7	25	17	13
.420		6	4	8	7	21	8	3	17	3	8
.250		6	1	14	13	7	14	1	8	1	7
.105		4		3	4	1	1	1	4	5	2
.074		1		2	2	0	3	0	1	1	1
50 Micron		0		0	0				0	0	0
5 Micron											
2 Micron											

*Station 5 located in a large boulder area.

surface fines (Figure 10) with streambed depth fines shows close similarity. Except for stations 20 (Dime Creek) and 25 (Goat Creek), the information supplied by both techniques follows the same trends.

Streambed Core Sample Analysis in Redds

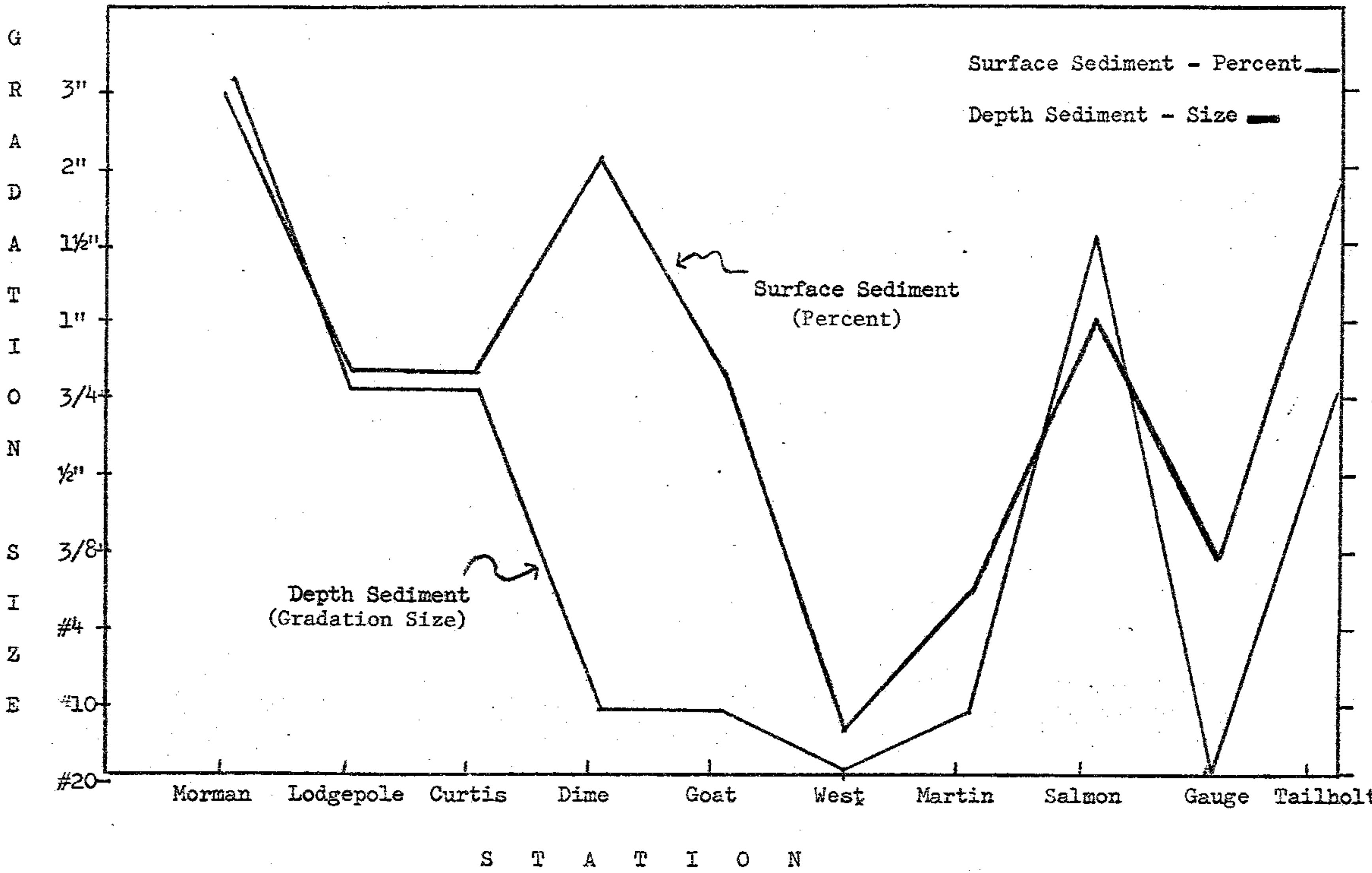
The spawning ground materials were analyzed by gradient class for samples collected in redds only, samples collected nonredds only, and samples collected randomly through the spawning area. No gradient class in the redd group tested significant at the 90 percent level; however, percent of rubble and gravel tended to increase and the sand classes tended to decrease in all cases from 1965 through 1972.

The rubble class in nonredd cores tested significant at the 95 percent level for an increase in percent at a rate of 2.35 percent/year. Also, the coarse sand class tested significant at the 90 percent level for a decrease at a rate of 1.83 percent/year. No other gradient class in nonredd group was significant.

When redd and nonredd data was grouped and analyzed, the coarse sand classes tested significant at the 90 percent level for a decrease in coarse sand at 1.13 percent/year and total sand percent tested significant at the 95 percent level for a decrease of 2.5 percent/year.

Trends in depth material size between redds and nonredds are as follow: In 1967, there were no significant trends in material size between redd and nonredd areas; however, in 1969 an interesting trend developed

Figure 10 Comparison of streambed surface sediment content with streambed depth sediment content at individual stations located in the South Fork Salmon River, 1967.



between redd and nonredd areas. The redds tested significantly higher for percent gravel and significantly lower for percent fine sand. This held true in 1970 and again in 1971 (Figures 11 and 12). For each depth core sample a D_{50} factor was determined. The D_{50} is the size in m.m. in which 50 percent of the material was larger and 50 percent of the core material was smaller. A linear regression for this data (redd plus nonredd) resulted in a significant test at the 95 percent confident interval for an increase in size at 3.27 m.m/year (Figure 13). This is evidence that the size class of the depth material is increasing on the SFSR stream channel. The D_{50} factor eliminates the effect one size class may have on a mean and is a measurement of central tendency or median size.

Spawning Conditions

To survive, the salmonid embryo and alevin must constantly receive ample supply of oxygenated water of suitable temperature and free of toxic materials. Water chemistry analysis (Appendix III) eliminates, under present conditions, the possibilities of detrimental influences from toxic materials other than fines. Field tests made (not published) determined that surface water contains more than adequate dissolved oxygen content. The small amount of water temperature data available (Appendix V) shows no detrimental influences. No studies have been made in the spawning areas to determine subsurface waterflows and carbon dioxide and oxygen content.

Figure 11 Trends in depth samples between redd and nonredd areas at the Poverty monitoring station 1967.

"t" Level for test in differences in means.

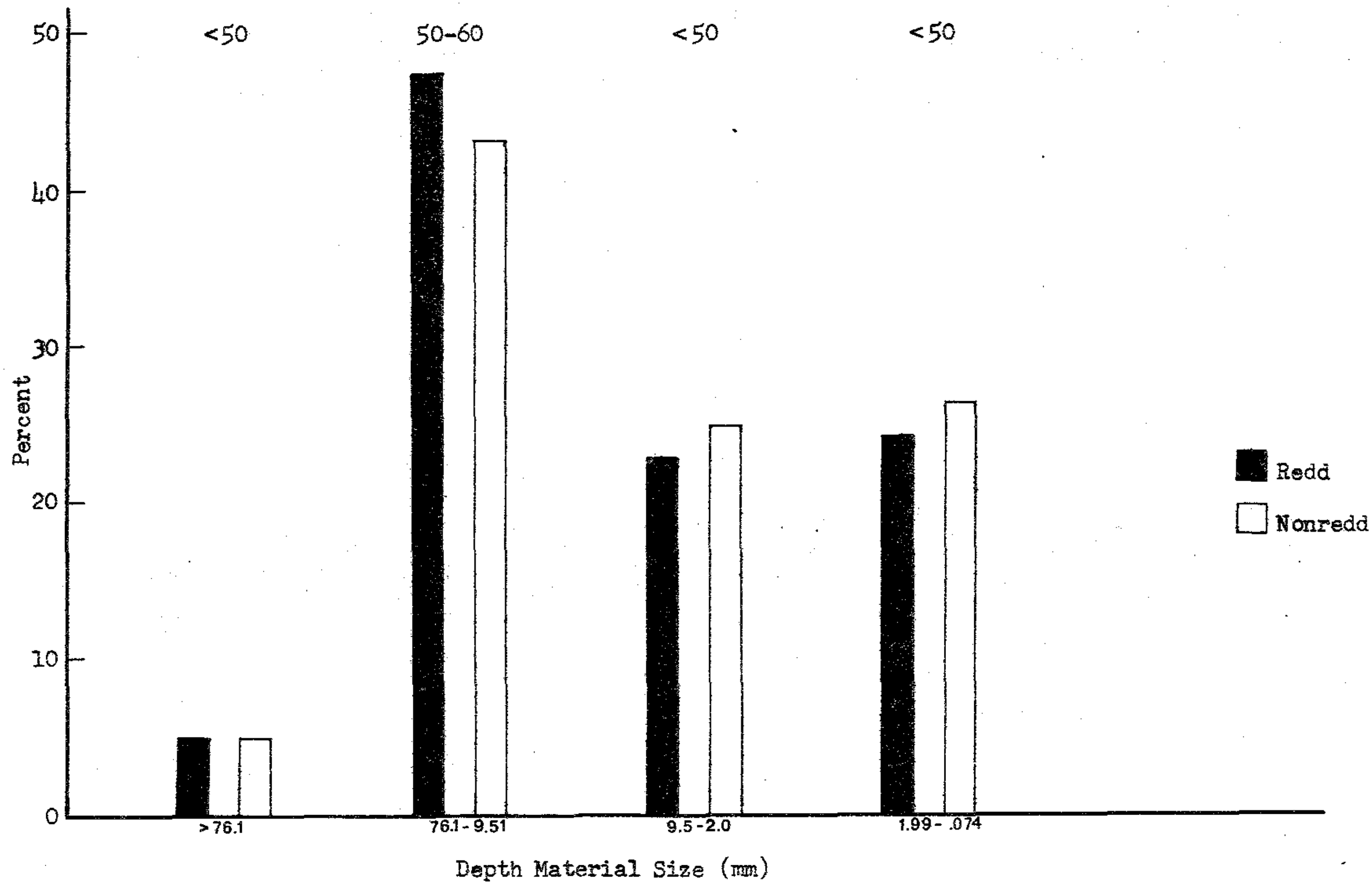
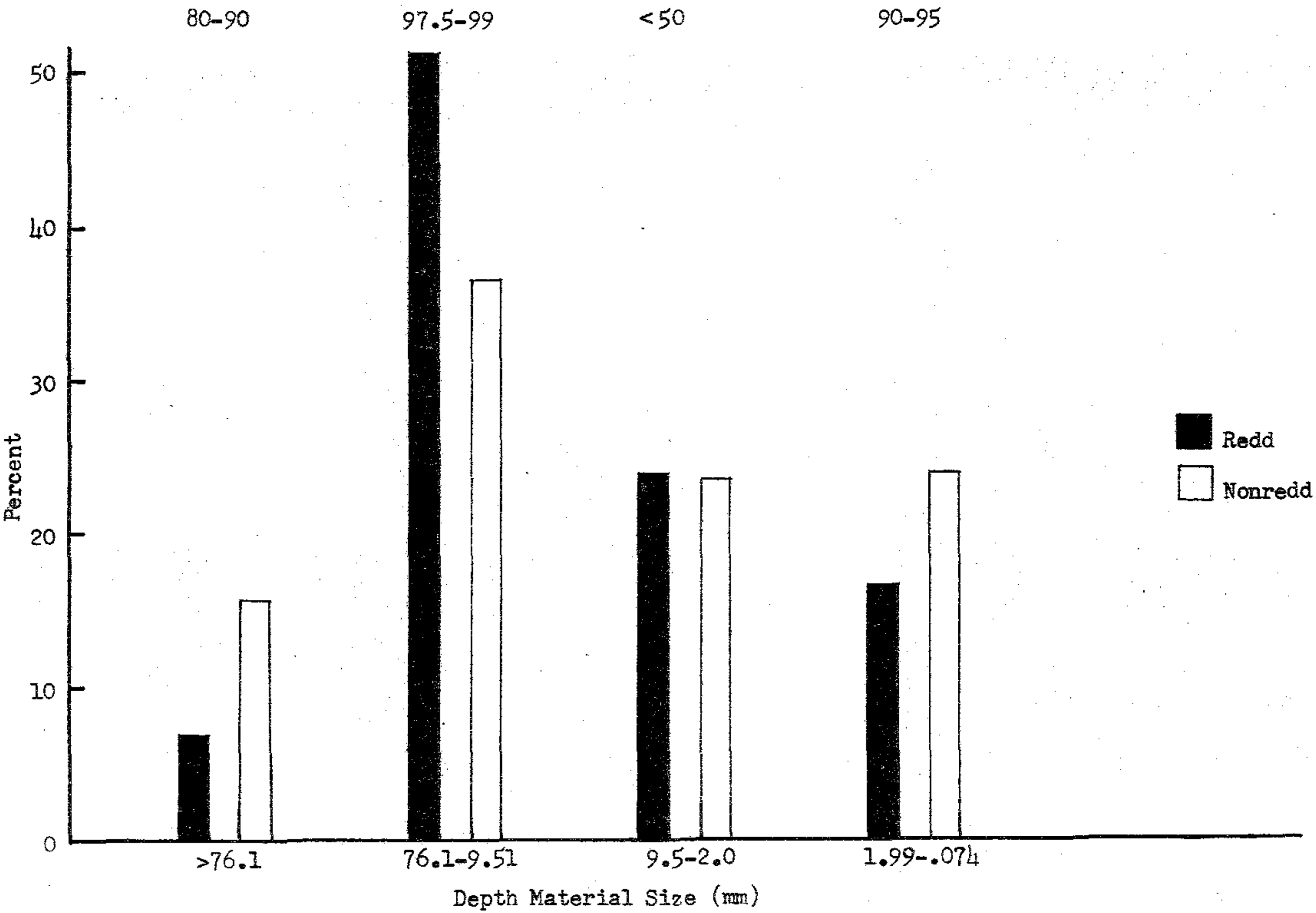
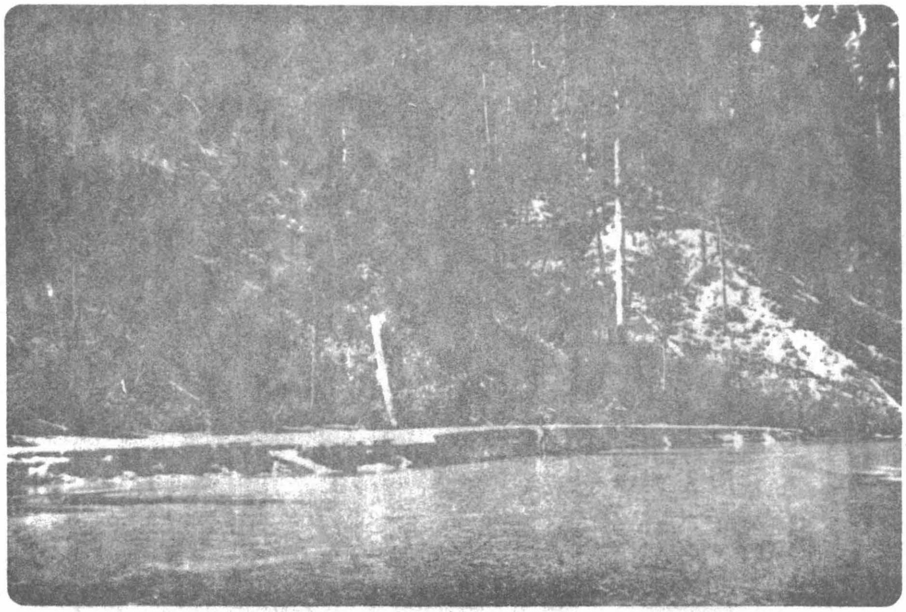


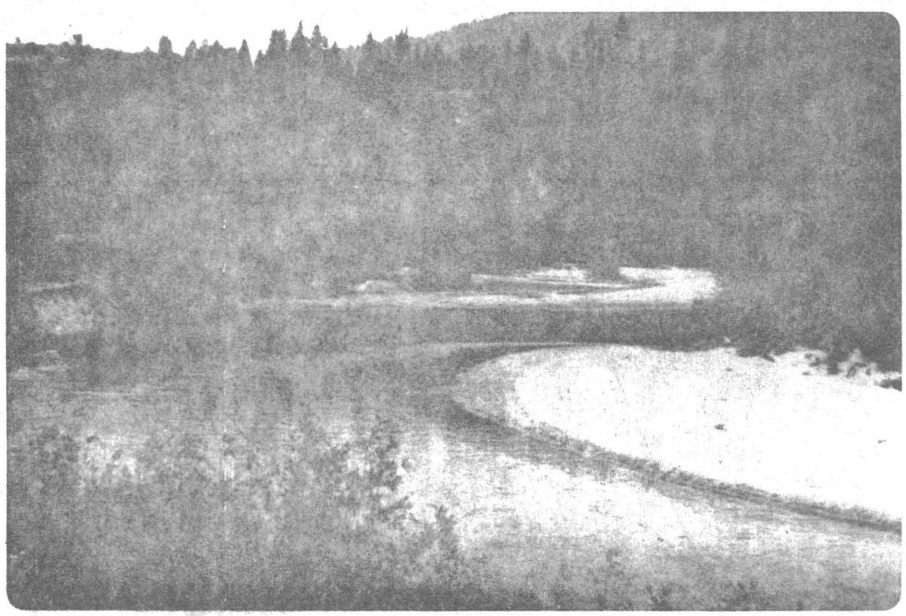
Figure 12 Trends in depth samples between redd and nonredd areas at the Poverty monitoring station 1970.

"t" Level for test in differences in means.



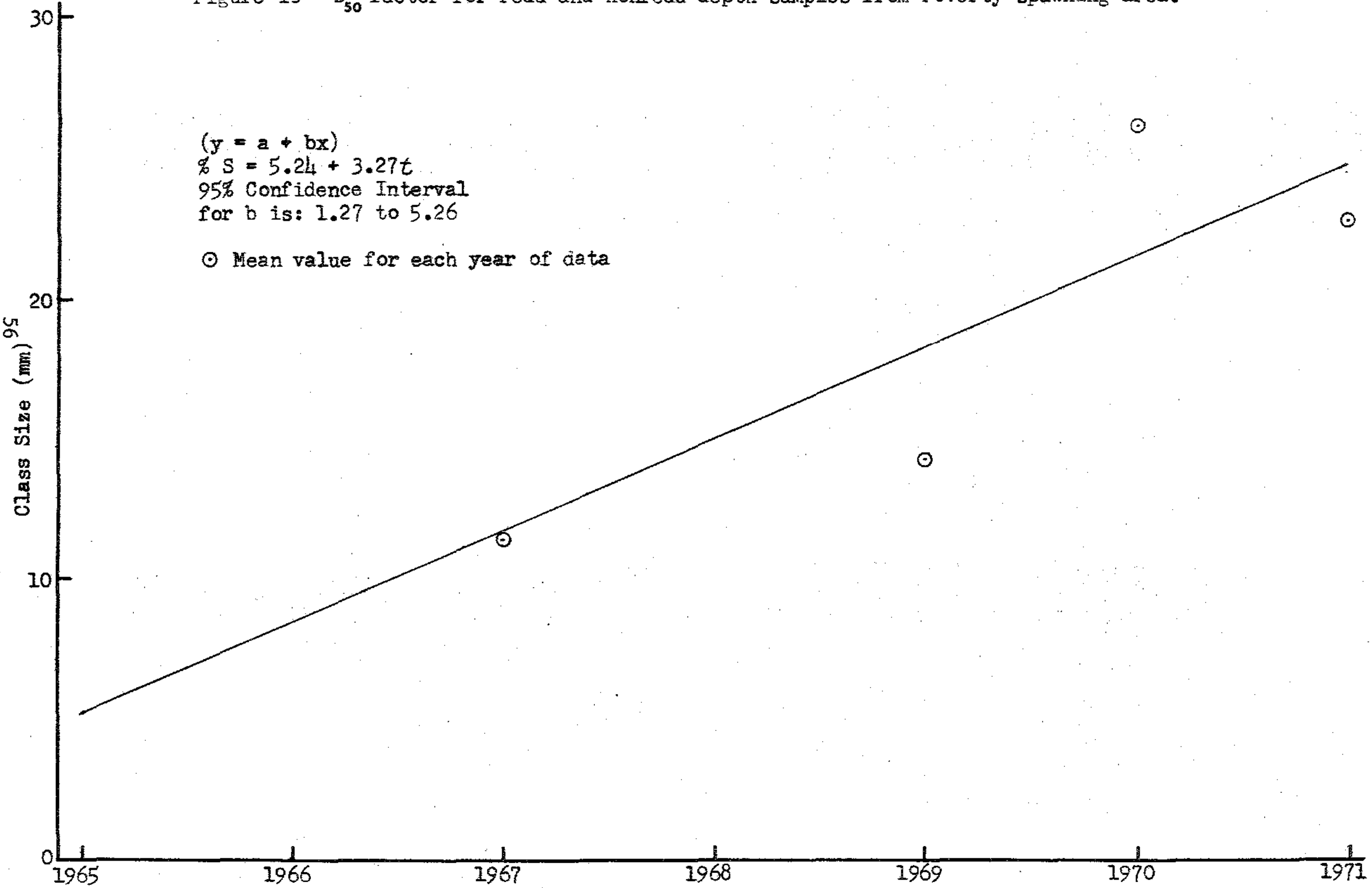


Photograph 19 - Sediment deposits in 1965 above the swimming hole. Deposits were up to 6 feet in depth.



Photograph 20 - Sediment deposits still exist (1972) in the area above the swimming hole, but not near the magnitude of 1965.

Figure 13 D_{50} factor for redd and nonredd depth samples from Poverty spawning area.



Observations (1965-1970) and sampling show that layers of downstream moving fines have deposited on and covered certain spawning areas to a depth that prevents surviving fry access to surface water. The fry in the intergravel environment that survive to the hatching stage must find sufficient interspaces between the spawning gravels to provide unobstructed passage to the surface waters. Conditions during 1965 through 1970 were definitely a mortality factor.

The major salmonid spawning areas occur in the upper half of the SFSR where stream gradients are lower and streambottom materials smaller than the overall average. The female must find sufficient materials small enough for her to dislodge and move and yet be large enough in size to provide the necessary water permeability. Gravel and fine content in spawning areas are about the same as found in the overall stream, but understandably boulder content is nine times higher in the overall stream than within the spawning areas (1967).

Sediment Size

It has been substantially documented that size composition of streambed materials greatly influence the waterflow and quality bathing the embryos and alevins. The potential of a salmonid spawning area to produce fry to surface waters is directly related to the permeability in the intragravel areas.

Photograph 21 - The SFSR at the Stolle area showing magnitude of high water the past 2 years. High flows and high gradient make competency high in most areas of the river.

McNeil (1964) found that permeability of spawning materials is high when bottom materials contain less than 5 percent by volume material that would pass through a 0.833 m.m. sieve. Low permeability was found to occur when bottom materials contained more than 15 percent material passing through a 0.833 m.m. sieve. Sheridan (1964) also placed the dividing line at 0.833 m.m. in separating impermeable materials. In 1967, the SFSR spawning areas fell into the low permeability range as demonstrated by other studies. The author feels, however, that the SFSR spawning areas (1967-1970), although having low permeability, are further degraded by blockage of fry emergence by the blanket of fines. In 1967, 20 percent of the spawning ground materials were fines below 0.833 m.m. in particle size which would cause low water permeability. This would classify the SFSR spawning areas as very poor in survival potential.

Studies with salmon eggs in the Robertson Creek artificial spawning channels (Lucas, 1960) showed spectacular spawning success of 90 percent when silt and other fines were absent. Furthermore, it was suspected from their results that the exclusion of all materials less than 12.5 m.m. will greatly increase survival. However, Bjornn (1966) found optimum survival of eggs when fines accounted for 10 percent of the spawning materials.

I believe that particle size causing damaging effects in the SFSR ranged higher than 0.833 m.m. During the period 1967 through 1970, bedload sediment not only changed the spawning areas by filling streambottom material interspaces, but in many cases it completely blanketed the surface of the spawning areas. Following 1964-1965 storms, spawning areas were blanketed with up to 4 feet of bedload sediment (see photographs). Sediment of this quantity was damaging even though a high percentage of the particles were above the 0.833 m.m. diameter size. In analyzing the detrimental effects of fines in the SFSR drainage, the author believes that the particle sizes that caused excessive damages were material 4.75 m.m. in particle diameter or less.

FISHERY

Salmon Numbers

Salmon redd counts in the SFSR since 1955 have declined significantly (Table 10 and Figure 14). The redd counts made the last 3 years (1969-1971) in the SFSR averaged about five times lower than the redd counts made the first 3 years of counting (1955-1957). Based on this data, recent salmon runs are from runs that suffered very little mortality due to the commercial and sport fisheries. However, these runs did suffer heavy mortality from hydroelectric complexes.

The Stolle Meadows, Poverty, and Oxbow areas supported 81 percent of the SFSR summer chinook salmon spawning during 1967. Salmon, because of basic requirements for spawning purposes, are forced to utilize

Table 10 Annual salmon redd counts, SFSR drainage and total Idaho count.

Year	South Fork Salmon River	Johnson Creek	Secesh River and Tributaries	Total Idaho
1954				6,242
1955	2,746	503	127	9,394
1956	2,067	436	358	8,608
1957	2,756	349	344	13,689
1958	1,218	265	449	6,805
1959	1,305	295	248	5,818
1960	2,306	517	517	9,825
1961	1,058	207	198	9,670
1962	1,589	297	292	8,641
1963	1,057	266	163	7,256
1964	1,124	310	181	7,157
1965	656	116	134	3,738
1966	980	110	140	7,127
1967	854	286	140	7,444
1968	515	127	58	6,531
1969	636	273	104	3,962
1970	527	130	63	4,442
1971	421	183	80	3,883
1972	577	220	87	5,155
Average	1,244	272	205	7,126
High	2,756	517	517	13,689
Low	421	110	58	3,738

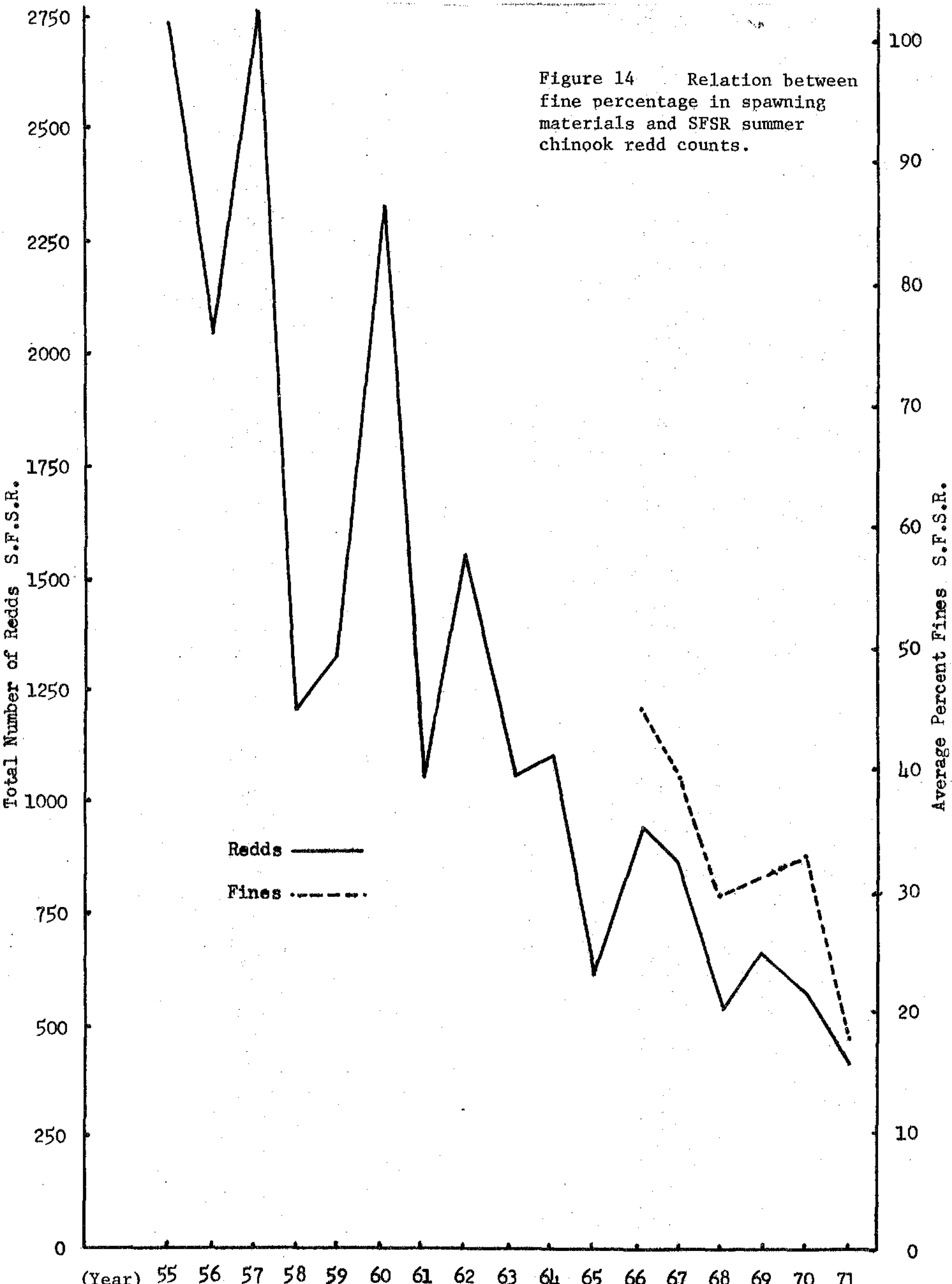


Figure 14 Relation between fine percentage in spawning materials and SFSR summer chinook redd counts.

that area of the South Fork Salmon River which has a low stream gradient which also results in higher than average fine content of the streambottom materials.

To date, excluding the resident fishery, no benefits in salmon numbers can be seen due to the river moving towards better condition (Figure 14). Because of the 4-year cycle in salmon populations, the retardation that may occur in biotic communities returning to natural conditions, and the overshadowing of downriver limiting factors, it will take time for these runs to be enhanced from better river conditions.

DISCUSSION

The SFSR is a prime example of what happens when a watershed is over-disturbed by logging and road construction. Because summer chinook utilize the system, this overdisturbance gained concern on the national level. This concern allowed these studies to be done. Hopefully, the findings in this study will have application in other drainages, as we have many streams that are in worse condition than the SFSR.

I contribute the destruction that went on in the SFSR aquatic environment to poor land management practices. I believe one of the major items leading to poor management of the watershed was lack of a multidiscipline approach to making land management decisions. Even after 1965, after the bust in the SFSR drainage, logging sales and road construction was continued above the confluence of the Secesh River, but I know of no instance where fishery biologists were asked to enter in on a team approach as to how a certain proposed logging sale or proposed road construction project would effect the river or its tributaries. If this situation is not corrected in the future, my prediction that the SFSR will return to near-natural conditions within the decade is not a valid prediction

CONCLUSIONS

1. The SFSR has shown a remarkable ability to regain its natural condition. If, in the near future, there are no major storms and no additional man-caused disturbed lands or large fires, the SFSR should be in good condition within a 10-year period.

2. The content of fines in the spawning areas from 1965 through 1970 was high enough to have caused increased mortality in salmonid eggs, embryos, and alevins during their life period within the streambed materials.

3. The SFSR is capable of eliminating large amounts of fines from its system.

4. The SFSR stream channel, during 1962 through 1971, contained more fines than is conducive to good environmental conditions.

5. Fines on the streambed surface and within streambed depth materials is still at levels that are detrimental to the aquatic environment and its fishery resource.

6. Bedload sediment is the major factor damaging to the SFSR aquatic environment.

7. The salmonid carrying capacity of the SFSR was reduced.

8. The SFSR lost its ability during 1965-1970 to contain necessary amounts of downstream moving fines during low flows, but regained this ability in 1971.

9. Suspended sediment content is having very little effect on the aquatic environment when compared to effects from bedload sediment.

10. The SFSR is lacking in good pool area, but most of this is due to natural conditions.

11. The SFSR streambanks are stable and in good condition.

RECOMMENDATIONS

1. In all future land uses that would place segments of the watershed in a disturbed condition or would place stress on the aquatic environment, a multidiscipline team should study all facets and enter into the decisionmaking processes as to (a) if the land use should be allowed; and (b) if so, how it should be accomplished. On this team there should be at least one fishery biologist meshed with the other disciplines.

2. Until methods have been perfected to utilize the land resources that will not cause watershed or stream disturbance are demonstrated in similar areas, they should not be attempted in the SFSR drainage.

3. Accelerated sediment recruitment to the SFSR should continue to be reduced, where feasible, to the point that the movement and containment of fines will be compatible with good aquatic environmental conditions.

4. The Idaho Zone Fishery Biologist, in cooperation with the Idaho Fish and Game Department regional fishery biologist, should continue to evaluate the system in the SFSR drainage to monitor the aquatic environment and its fisheries.

5. The streambed materials in the major salmonid spawning areas should be more intensively studied for water permeability, oxygen and carbon dioxide levels, and movement of materials.

6. More intensive studies on resident fish populations should be conducted.

BIBLIOGRAPHY

1. Anonymous. "Status Report on The Columbia River Commercial Fisheries, Fish Commission of Oregon - Washington Department of Fisheries." January 1965, p. 88, 1964.

2. Anonymous. "Annual Fish Passage Report, North Pacific Division, Bonneville, The Dalles, McNary and Ice Harbor Dams, Columbia and Snake Rivers, Oregon and Washington, U. S. Army Engineer Districts - Portland and Walla Walla." 1965.

3. Bagnold, R. A. "The Flow of Cohesionless Grains in Fluids." Phil. Trans. Roy. Soc. Lond., Vol. 249, pp. 235-297, 1956.

4. Cooper, A. C. "The Effect of Transported Stream Sediments on The Survival of Sockeye and Pink Salmon Eggs and Alevin." Int. Oac. Salmon Fish Comm., Bul. 18. pp. 71, 1959.

5. Cordone, Almo J., et al. "The Influences of Inorganic Sediment on The Aquatic Life of Streams." Calif. Fish and Game, Vol., 47, No. 2, pp. 189-228, 1961.

6. Croft, A. R., et al. "R-INT Inspection of 1949 Payette Forest Fires." Memo. 3-17-50, 1950.

7. Hockaday, James. Payette National Forest Correspondence, 10-18-1965, File No. 2510. GII Inspection Report, 1965.

8. Jensen, Frank, et al. "Hydrologic Analysis Report of the Zena Creek Logging Study Area," USDA, U. S. Forest Service, Intermountain Region, pp. 123, 1966.

9. Jensen, Frank, et al. "South Fork of The Salmon River Storm and Flood Report," USFS mimeo, R-4, pp. 15, 1965.

10. Platts, William S. "South Fork Salmon River, Idaho, Aquatic Habitat Survey With Evaluation of Sediment Accruement, Movement, and Damages." USFS, R-4, Mimeo, pp. 137, 1968.

11. Richards, Monte. "Management of The Chinook Salmon Fishery of the South Fork Salmon River Drainage." Idaho Wildlife Review, July-August 1963.

12. Shaw, Paul, et al. "The Effect of Moving Silt on Yield of Fry from Salmon Spawning Beds." Calif. Fish & Game, Vol. 29, No. 1, pp. 29-41, 1943.

13. Vasil'en, I. S. "Water Supply of The Redds of Pink Salmon and Summer Chinook Salmon." Biol. Abst., Vol. 45, No. 2, Abst. 5015, 1964.

14. Wickett, W. P. "Review of Certain Environmental Factors Affecting The Production of Pink and Chum Salmon." Journ. Fish. Res. Bd. Canada, Vol. 15(5) pp. 1103-1126, 1958.

15. Whitt, Charles. "South Fork Salmon River and Tributaries Stream Habitat Survey." USFS, Boise National Forest, Mimeo. pp. 11, 1962.

APPENDIX I

Methods, Techniques, and Equipment

Methods, Techniques, and Equipment

Aquatic Environment Physical Studies

The methods and techniques for the aquatic environment survey follow, with modifications, those outlined by Herrington et al. (1967) in Research Paper INT-41. Herrington found that results from the techniques and methods, when tested on three streams, provided acceptably precise estimates of stream width, stream surface area, pool area, riffle area, stream depth, and streambed composition, as well as estimates of the stability and vegetative cover of the streambanks. Modifications of the methods and techniques used by Herrington were used to better evaluate such things as spawning areas, streambed depth materials composition, sedimentation influence, and spatial and temporal changes in and between stream channel areas.

Stations

Because of different land types, soils, terrain, streamflows, stream gradient, and stream types found within the river, it was stratified in an attempt to isolate more homogeneous study areas (Figure 2). The river was stratified into eight study areas. Within each area, an average of eight stations were chosen,(40 transects) averaging about one station per mile. It was a basic assumption that the total information collected would determine the aquatic habitat status for the complete river and also within each study area. Each station was

located a known distance from a permanent landmark so future studies or monitoring to determine temporal changes could be conducted using approximately the same station location. Exceptions to this procedure were the first 25 stations located from the headwaters of the SFSR downstream to and including the Knox area. These stations were located as designated in the 1962 Upper SFSR Aquatic Habitat Survey (Whitt, 1962). This allowed data from the two studies to be compared for temporal changes that might have taken place in the aquatic habitat from 1962 to 1971. All stations run in 1967 and 1962 were studied again.

In order for the stations to meet randomness required for statistical analysis, the actual station location was determined from a permanent landmark with use of a table of random numbers. The tables were used to dictate the exact distance the station would be located upstream from the permanent landmark, thus, the actual site of the station could fall anywhere between the permanent landmark and 1,500 yards upstream.

The station, once established, was marked on an aerial photograph. The station was then found on the ground with the use of the photograph. To avoid any bias resulting from locating the stations with use of aerial photographs, the first station transect was located 100 feet upstream from the photograph location. Once located, the station was marked for future use.

The river stations were studied in 1967-1971 and again in 1972. This report covers only the 1967 and 1971 information. Part of the monitoring stations were read each year except 1969. (1967-1972.)

Transects

At each of the 67 study stations, five stream transects were evaluated and measured for an overall total of 335 transects for the entire drainage (Tables 11 and 12). To document conditions in the spawning areas, additional monitoring stations were studied each year except in 1969. Monitoring stations were located at the Glory, Krassel, Oxbow, Darling, Poverty, Lower Stolle and Upper Stolle areas. Only the Glory, Krassel, Poverty, Lower and Upper Stolle areas were studied consistently.

The five stream transects within each station were located 50 feet apart. Transects were run from bank to bank at a 90° angle to the centerline of the stream. The following measurements and condition factors were taken:

1. Stream, pool, and riffle width to nearest foot.
2. Average stream depth to nearest inch.
3. Pool rating, location, and feature (table 13).
4. Aquatic vegetation.
5. Streambed surface and depth (to 6 inches) material classification.
6. Streambank cover, condition, and type.

Table 11 A breakdown of study area, station numbers within study areas and number of transects per study area.

Study Area	Station Numbers*	Transects
Upper SFSR	1-7	35
Stolle Meadows	8-12	25
Knox	13-25	65
Poverty	26-34	45
Oxbow	35-41	35
Krassel	42-47	30
Secesh	48-57	50
Mackay Bar	58-67	50
	Subtotal	335
Monitoring Stations		
Poverty		10
Glory		10
Krassel		10
Oxbow Spawning Area		10
Darling		10
Stolle Meadows (Lower)		10
Stolle Meadows (Upper)		10
	Subtotal	70
	TOTAL	405

*See map inserts in Progress Report I for station locations.

Table 12 South Fork Salmon River stations, transects, permanent landmarks, and streambed depth sample stations.

Area	Station	Landmark	Upstream Position (yards)	Streambed Samples (1967)
Upper South Fork	1	Above Upper South Fork Bridge	*	5
	2	Below Upper South Fork Bridge	*	
	3	Back Creek	*	
	4	Back Creek	*	
	5	Mormon Creek	*	5
	6	Section 23-14	*	
	7	Section 13-12	*	
Stolle	8	Vulcan Hot Springs Creek	*	
	9	Stolle Meadows	*	
	10	Lodgepole Creek	*	5
	11	Above Camp Creek	*	
	12	Below Camp Creek	*	
Knox	13	Bear Creek	*	
	14	Below South Fork Plunge Bridge	*	
	15	Curtis Creek	*	5
	16	Knox Bridge	*	
	17	Cabin Creek	*	
	18	Two Bit Creek	*	
	19	Six Bit Creek	*	
	20	Dime Creek	*	5
	21	Above Nickel Creek	*	
	22	Below Nickel Creek	*	
	23	Dollar Creek	*	
	24	Roaring Creek	*	
	25	Goat Creek	*	5
Poverty	26	Twin Creek	1,100	
	27	Snowslide Creek	800	
	28	Silver Creek	900	
	29	Poverty Recreation Site	700	
	30	West Drainage - 3	600	5
	31	Holdover Creek	100	
	32	Four Mile Creek	300	
	33	Lodgepole Recreation Site	400	
	34	Nasty Creek	400	
Oxbow	35	Martin Creek	1,400	
	36	Camp Creek	500	
	37	West Drainage - 9	600	5
	38	Buckhorn Creek	1,000	
	39	Buckhorn Bar Recreation Site	1,400	
	40	Salmon Point Recreation Site	900	5
	41	Wildcat Creek	1,200	
Krassel	42	Krassel Pack Bridge	1,500	
	43	Krassel Hole II	Pre-Set	10
	44	Krassel Hole I	Pre-Set	10
	45	Water Gauge	300	5
	46	Fitzum Creek	700	
	47	East Fork Confluence	700	
Secesh	48	Secesh River	1,500	
	49	Hamilton Creek	400	
	50	Tailholt Creek	400	5
	51	Three Mile Creek	1,000	
	52	Pidgeon Creek	400	
	53	Fritzer Creek	100	
	54	Rock Creek	700	
	55	Elk Creek	800	
	56	South Fork Guard Station	1,300	
	57	Pony Creek	1,400	
Mackay	58	K Creek	300	
	59	Deering Creek	100	
	60	Smith Creek (Big Buck Creek)	300	
	61	Porphry Suspension Bridge	600	
	62	Chicken Creek	500	
	63	Rooster Creek	700	
	64	Raines Creek	1,500	
	65	Suspension Bridge Station Creek	300	
	66	Bradley Creek (Mill Creek) correct stream	800	
	67	Mackay Bar	1,400	

Table 13 Pool quality rating guide.

Pool			
Quality class No.	Length or Width	Depth	Shelter[1]
1	Greater than a.c.w.[2]	2' or deeper	Abundant[3]
	Greater than a.c.w.	3' or deeper	Exposed[4]
2	Greater than a.c.w.	2' or deeper	Exposed
	Greater than a.c.w.	<2'	Intermediate
	Greater than a.c.w.	<2'	Abundant
3	Equal to a.c.w.	<2'	Intermediate
	Equal to a.c.w.	<2'	Abundant
4	Equal to a.c.w.	Shallow[6]	Exposed
	Less than a.c.w.	Shallow	Abundant
	Less than a.c.w.	Shallow	Intermediate
	Less than a.c.w.	<2'	Intermediate
	Less than a.c.w.	2' or deeper	Abundant
5	Less than a.c.w.	Shallow	Exposed

1. Logs, stumps, boulders, and vegetation in or overhanging pool, or overhanging banks.
2. Average channel width.
3. More than 1/2 perimeter of pool has cover.
4. Less than 1/4 of pool perimeter has cover.
5. 1/4 to 1/2 perimeter of pool has cover.
6. Approximately equal to average stream depth.

Streambed Surface Material Composition

The streambed surface material composition was determined by direct measurement of the surface materials. The streambed transect was broken down to 1-foot intervals, the dominant surface material determine the 1-foot breakdown. For example, if within the 1-foot interval there was 8-inch fines, 2-inch gravel, and 2-inch rubble, the 1-foot measurement would be completely classified as fines. On each transect the streambed surface material was measured and classified according to the following guidelines (Table 6):

1. Boulder - 304.8 mm. or over in diameter.
2. Rubble - 76.1 mm. to 304.7 mm. in diameter.
3. Gravel - 4.7 mm. to 76.0 mm. in diameter.
4. Fines - less than 4.7 mm. in diameter.
5. Other materials (logs, debris, etc.). (Only used at

beginning of study and dropped. If other materials were found, the substrate under it was used for classification.)

Pool-Riffle

Stream area was stratified as to pool and riffle. The pools in turn were classified as to suitability to fish habitat based on the criteria outlined in Table 13. Riffle and pool area was measured to the nearest foot and the two equaled the stream width.

Streambank Conditions

Bank conditions at both ends of each transect were rated as excellent (2.0), good (1.5), fair (1.0), and poor (0.5) and each breakdown given a numerical equivalent (Table 14). Streamside cover and type (vegetation, boulder, etc.) were rated as forested (2.0), brush (1.5), grass (1.0), and exposed (0.5) and each broken down and given the numerical equivalents indicated (Table 14). The specific measurements obtained and analyzed in this report encompassed only the point of the transect intersection with the bank in the 1967 study. In 1971 and 1972, cover included the area 50 feet upriver and 50 feet downriver from the transect point. Both come out the same if sample size is large enough.

Herrington, in streambank evaluation, used an area of approximately 200 feet square at each end of the transect above the high water mark to determine streambank conditions.

Streambed Depth Materials Composition

The streambed depth composition was determined by sampling the bed to a depth of 6 inches with the use of a 6-inch diameter streambed depth core sampler. The purpose of sampling was to determine present depth composition and detect any spatial and temporal changes in material composition. It is very important to be able to define the conditions and changes that were taking place in the spawning areas. Five streambed core samples were collected, one on each transect, at every fifth station in 1967 from the SFSR headwaters downriver to its confluence

Table 14 Numerical ratings used to classify streambank cover, condition and type.

Cover		Condition		Type	
Forested	2.0	Excellent	2.0	Boulder	2.0
Brush	1.5	Good	1.5	Brush-Rubble	1.5
Grass	1.0	Fair	1.0	Grass-Gravel	1.0
Exposed	0.5	Poor	0.5	Fines-Debris	0.5

with Tailholt Creek. The riverbed below the Tailholt Creek confluence became dominated by large rubble and boulders and from this point downstream the sample equipment would not work.

On the first transect, the sampler was worked down into the streambed to a depth of 6 inches. The core was dug out by hand and deposited in a built-in basin. A cap was placed over the core tube to prevent water and sediment in suspension from escaping. The sample, plus the trapped water, was then strained through double flour sacks. Some of the fines could be observed passing through the cloth, but for the purposes of this study is considered insignificant.

A series of samples were collected where the fines within the trapped water was allowed to settle out in plastic containers and all fines measured. It was found, because of the very small amount of fines (less than 1 percent below .074 mm. in diameter), that the techniques of straining through double flour sacks obtained very close to the same findings. In a streambed containing high amounts of silt and clay, the complete water sample would undoubtedly need to be trapped and the silt and clay allowed to settle out and be measured in order to obtain accurate results. It was also found in direct sampling of the Krassel excavation and fine accruement materials that material below .074 mm. were almost totally absent.

The core sample material was separated into 16 size classes: solids were strained through sieves and fines collected for further hydrometer

analysis as shown on Table 6. The actual volume of materials collected was expressed as percent of total so all samples could be compared.

The samples were analyzed by the USFS Materials Laboratory, Division of Engineering, Salt Lake City, Utah. Mr. Gerald Wilson handled this phase of the study.

Methods and Technique Difficulties

The survey methods and techniques used in this study worked very well until water depths exceeded 48 inches or water velocities became excessive. This started occurring in the SFSR below its confluence with the Secesh River. From the confluence of the Secesh River downstream, measurements such as depth, width, streambed surface composition, which required direct measurements, had to be estimated by ocular inspection in areas where water depth was over 48 inches or water velocities became excessive. Water conditions were very clear and low, offering excellent observation, but the ocular estimates for portions of the data should be considered when evaluating the findings in the SFSR below the confluence of the Secesh. The author feels the estimated portions of aquatic habitat data, because of ideal survey conditions, are accurate enough for both documentation of present conditions and comparison with future conditions.

Computer Analysis

The streambed surface material data for the eight study areas was analyzed using the student's "t" test to find a significant difference

in means in data between 1967 and 1971. A 90 percent level of "t" was assumed significant in the analysis.

A simple linear regression was used to evaluate the monitoring station data. Depth samples were analyzed with a student's "t" test and simple linear regression for the size classes. Also, a size class in which 50 percent of the sample was held by a sieve and 50 percent of the sample fell through the sieve was found (D_{50} factor) and analyzed with the following computation programs from the GSA time-sharing library.

STAT01 ***

STAT02 ***

CØLINR ***

APPENDIX II

Stream and Study Area Description

Stream and Study Area Description

The SFSR, located in west-central Idaho within the Idaho Batholith, is a primary tributary to the Salmon River. It enters the main Salmon River approximately 133 miles above the confluence of the Salmon and Snake Rivers. The drainage is a long, narrow, north-flowing stream composed of three major streams - the SFSR proper, the Secesh River, and the East Fork South Fork Salmon River. The drainage is characterized by steep mountainous terrain and composed almost entirely of granitic materials in various stages of decomposition.

The waters within this drainage are classified as soft and low in productivity because of the dominant granitic watershed. Water hardness averages only 42 p.p.m. (as $CaCO_3$) and alkalinity only 28 p.p.m. (as $CaCO_3$). Nitrates (.39 p.p.m.) and phosphates (.39 p.p.m.) are also low.

Physiographically, the SFSR is a long, narrow drainage ranging in elevation from slightly over 9,000 feet in the headwaters to 2,000 feet at its confluence with the main Salmon River. The channel varies from about .5 percent stream gradient in the Stolle, Oxbow, Krassel spawning areas to 10 percent and above in stretches through the Knox, Secesh, and Mackay Bar areas. The river in 1967 averaged 74 feet in width and 23 inches in depth. Sixty-six percent of its area was in riffle and 34 percent pool. The main streambottom material is boulder (36 percent) followed by fines (26 percent). Rubble and gravel make up 21 and 16

percent respectively of the streambed surface composition. Surface fines and small gravel content in the major salmonid production areas averages 48 percent.

In 1971, the river averaged 77 feet in width and 24 inches in depth. Forty-nine percent of its area was in riffle and 28 percent pool. The main streambottom material is boulder (42 percent) followed by rubble (29 percent). Fines and gravel make up 18 and 11 percent respectively.

Because of its length, size, and elevation changes, the SFSR fulfills the necessary production and rearing requirements needed by anadromous and resident salmonids. The SFSR received very heavy fishing pressure during past salmon and steelhead seasons (up to 1964) and moderate pressure on the rainbow trout, cutthroat trout, Dolly Varden, and Whitefish. Nongame species include the sucker, dace, lamprey, and sculpin. The salmonid spawning areas are found mainly in the depositional streambottom lands. Much of the spawning materials have resulted from downstream movement of materials from the strongly and partially glaciated lands.

The climate is characterized by hot, dry summers, and cold, relatively moist winters during which 45-90 percent of the 36 inch mean annual precipitation falls as snow. Long duration (1-4 days) frontal rain storms producing up to 10 inches of precipitation occur in the area and have been a critical factor to flash flooding and extensive landslides during winter and spring months when there is snow on the ground. Streamflow is closely related to and influenced by winter snowfall and spring melt rates.

APPENDIX III

Hydrochemical Conditions

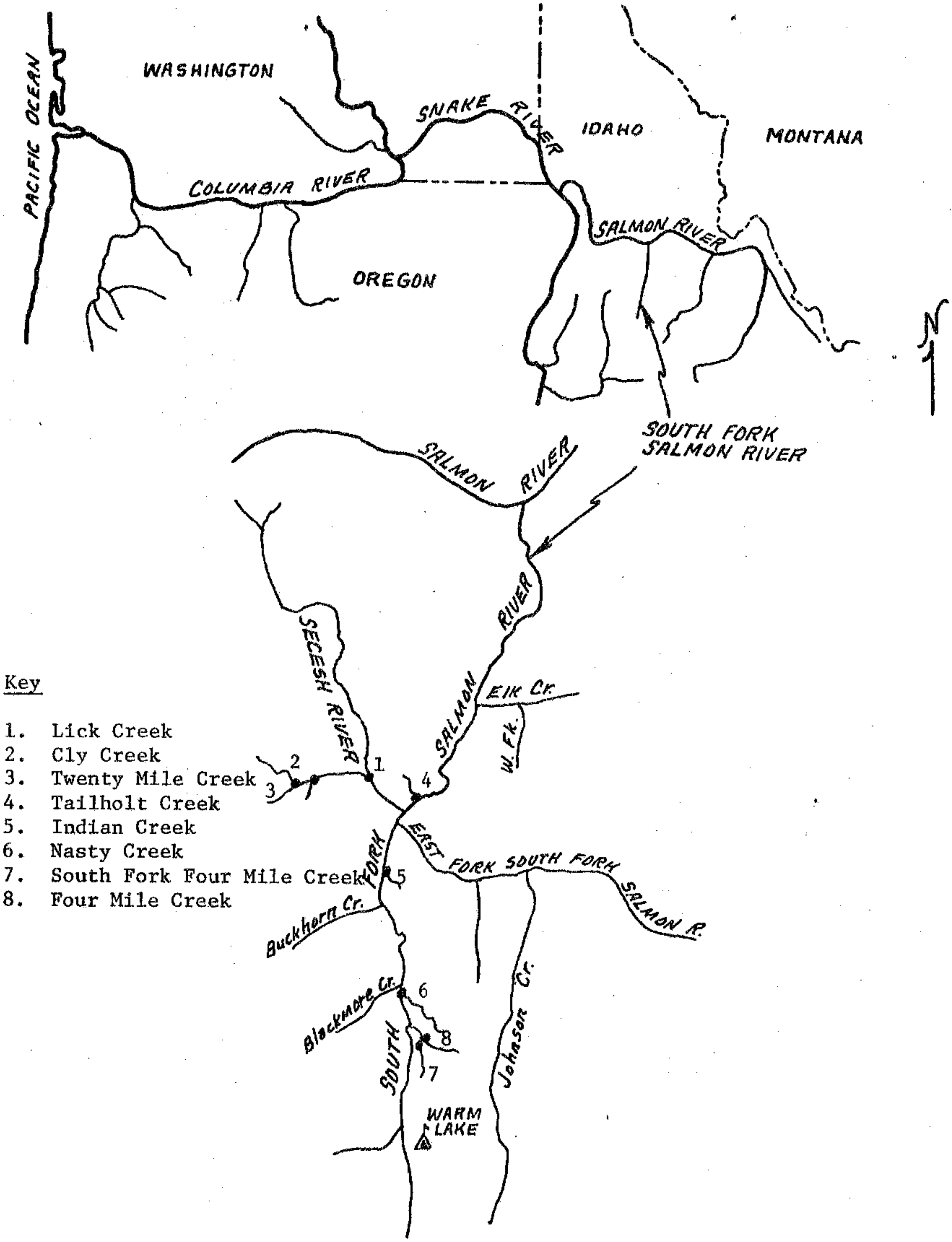


FIGURE 15 Location of hydrochemical sampling stations.

Table 15 Location of hydrochemical sampling stations in the South Fork Salmon River drainage.

Station Number	Stream	Sample Location
1	Lick Creek	Confluence north fork Lick Creek
2	Cly Creek	Mouth
3	Duck Lake Creek	Mouth
4	Tailholt Creek	Mouth
5	Indian Creek	Mouth
6	Nasty Creek	Mouth
7	South Fork Four Mile Creek	Mouth
8	Four Mile Creek	Above confluence south fork Four Mile Creek

Samples collected during 1970.

Table 16 Average chemical analysis of water samples collected from July through September 1970 in tributaries of the South Fork Salmon River by date (pH in units, remainder in parts per million).

Date	ph	Total Solids	Total Dissolved Solids	Alka	Hard	Ca	Mg	Fe	Mn	Na	Cl	SO_4	NO_3	PO_4	SiO_2	F	N	Zn	Cu	As	Ba	Cd	Cr	Pb	Ag	K	Total Ave.
7/6/70	7.34	59.50	40.50	26.50	21.50	4.50	2.63	.424	<.010	1.50	5.00	4.00	.338	.653	10.13	<.010	.078	.091	.055	<.010	<.020	.003	.031	<.01	<.013	.312	182.158
7/17/70	7.76	79.00	60.75	26.50	46.50	4.75	8.38	.041	.028	1.88	4.50	1.25	.303	.405	11.70	.031	.150	.007	<.001	<.010	<.020	<.001	.021	<.01	<.010	.263	254.281
8/5/70	7.81	74.50	58.00	29.00	21.50	4.88	2.38	<.019	<.010	2.75	3.00	<3.25	.650	.089	12.63	<.034	.475	<.001	<.002	–	–	–	–	<.01	–	.500	226.490
8/20/70	8.07	76.00	59.57	21.71	46.29	4.29	8.57	.090	<.010	1.29	5.57	<1.00	.200	.770	11.86	<.010	.100	.019	<.026	<.010	<.020	<.001	.020	<.01	<.010	.260	245.776
9/5/70	7.83	105.50	82.75	36.50	74.00	5.63	12.00	<.048	<.010	1.50	3.25	1.00	.475	.066	13.80	.133	.110	.007	<.003	<.010	<.020	<.001	.015	<.01	<.010	.238	344.916
Total	38.81	399.50	301.57	140.21	209.79	24.05	33.96	.622	.068	8.92	21.32	7.50	1.966	1.983	60.12	.218	.913	.125	.087	.040	.080	.006	.087	.05	.043	1.567	1,253.621
Average	7.76	79.90	60.31	28.04	41.96	4.81	6.79	.124	.013	1.78	4.26	1.50	.393	.397	12.02	.044	.182	.025	.017	.008	.016	.001	.017	.01	.009	.313	250.724

Table 17 Average chemical analysis of water samples collected from July through September 1970 in tributaries of South Fork Salmon River by station (pH in units, remainder in parts per million).

Station	pH	Total Solids	Total Dissolved Solids	Alka	Hard	Ca	Mg	Fe	Mn	Na	Cl	SO_4	NO_3	PO_4	SiO_2	F	N	Zn	Cu	As	Ba	Cd	Cr	Pb	Ag	K	Total Average
1	7.38	80.0	62.8	28.0	45.6	4.0	8.6	.576	<.010	1.20	4.0	1.4	.260	.398	8.76	<.034	.200	.089	<.066	<.010	<.020	<.001	.020	<.010	<.015	.160	253.609
2	7.38	67.2	54.4	23.2	38.4	3.6	3.6	.162	<.010	1.60	3.8	<1.0	.300	.254	3.00	<.010	.160	.029	<.022	<.010	<.020	<.001	.018	<.010	<.010	.260	208.456
3	7.26	56.8	41.4	18.4	26.4	2.0	5.8	.038	.010	1.00	5.4	1.6	.280	.158	2.76	<.012	.220	<.005	<.001	<.010	.020	<.001	.013	<.010	<.010	.160	169.768
4	8.38	104.8	80.2	49.6	56.0	11.2	6.6	<.022	<.010	2.40	3.0	1.2	.220	.426	17.10	<.068	.180	.005	<.001	<.010	<.020	<.001	.030	<.010	<.010	.400	341.893
5	8.16	90.4	67.2	36.0	42.4	6.4	6.2	.024	<.038	2.60	4.0	<1.4	.520	.660	20.62	.126	.166	<.002	<.001	<.010	.020	<.003	.020	<.010	<.010	.480	287.470
6	8.03	83.0	61.5	24.0	41.0	3.5	7.5	.030	<.010	2.25	4.5	2.0	.825	.340	17.63	<.060	.240	<.001	.002	<.010	.020	<.002	.043	<.010	<.010	.525	257.038
7	7.60	84.0	62.8	24.0	46.4	3.4	9.0	.096	<.050	1.80	4.4	1.4	.520	.370	15.54	<.018	.196	.003	<.001	<.010	.020	.001	.015	<.010	<.010	.260	261.920
8	7.90	74.4	52.6	21.6	38.4	4.2	6.8	.030	<.010	1.60	4.8	<1.6	.360	.478	11.84	<.012	.160	.034	.041	<.010	<.020	<.001	.020	<.010	<.010	.320	227.256
Total	62.09	640.6	482.9	224.8	334.6	38.3	54.1	.978	.148	14.45	33.9	11.6	3.285	3.084	97.25	.340	1.522	.168	.135	.080	.160	.011	.179	.080	.085	2.565	2,007.410
Average	7.76	80.1	60.4	28.1	41.8	4.8	6.8	.122	.019	1.80	4.2	1.4	.410	.385	12.16	.042	.190	.021	.017	.010	.020	.001	.022	.010	.010	.320	250.926

Table 18 Water quality analysis of South Fork Salmon River (p.p.m.) collected at Krassel on May 25, 1967, and average chemical composition (percent) of material of the Idaho Batholith.

	Water (ppm)	Material (percent)
Alkalinity (as $CaCo_3$)	8	
Aluminum		15.7
Calcium	4	3.0
Chloride	8	
Copper	.02	
Fluoride	.3	
Hardness (as $CaCo_3$)	53	
Iron	0	2.8
Magnesium	9	0.7
Manganese	0	
Nitrate	1.6	
Ph	6.6	
Phosphate	.7	
Pottassium		3.1
Silicon		70.5
Sodium	5	3.9
Sulphate	0	
Titanium		0.3
Total Solids	13	

Table 19 Total and suspended residue content (p.p.m.) in water samples collected above (Krassel Station) and below (Glory Station) the Krassel excavation.

	Krassel Station		Glory Station		
Date	Total	Suspended	Total	Suspended	Water Elevation
11/4/66	65	20	67	47	1.7
11/17/66	81	57	89	64	2.3
12/1/66	70	55	69	17	2.0
3/16/67	104	33	98	86	1.9
5/24/67	44	40	35	33	7.2
5/25/67	64	38	44	43	7.1
6/7/67	46	40	53	33	4.4
6/23/67	56	38	20	18	6.2
Average	66.25	40.12	59.37	42.62	4.1

APPENDIX IV

Glossary

Glossary

Anadromous	Uprunning; refers to fish such as salmon and steelhead that leave the ocean and ascend streams to spawn.
Benthic	Bottom living forms of aquatic organisms.
Carry Capacity	Maximum quantity of fish that a particular water can support over a long period of time.
Competency	The ability rating of a stream to eliminate sediment size.
Fines	In this report it refers mainly to inorganic material less than 4.7 mm in particle diameter size.
Gradation	Separation of materials by particle size.
Monitor	To establish a system of checks that will determine changes taking place within the aquatic environment.
Monitoring Stations	Non-random documentation transects (10 to the station) selected in key salmon spawning areas to determine temporal changes from year to year.
Production	The annual numbers of fish that can be produced from a given water area.
Random Samples	The samples collected for this study were taken in such a manner that every possible sample unit had an equal chance of being included in the sample.
Redd	The spawning nest which is excavated from the streambed materials, eggs deposited and then partially refilled with streambed materials.
River Stations	Randomly located transects (5 to the station) located from the headwaters of the SFSR to the mouth to detect temporal conditions of physical parameters.
Sediment	Any material transported by, suspended by, or deposited by water.
Sediment Bedload	That portion of the total sediment load whose immersed weight is carried by the solid bed and because of particle size and weight it does not readily flush out of the stream.
Sediment Surface	That sediment on the streambed surface that is determined by direct measurement with use of measuring tapes.
Sediment-Depth	That portion of the streambed to a depth of 6 inches.

Sediment-Suspended	That portion of the total sediment whose immersed weight is carried by the fluid and thus finally by the interstitial fluid between bed grains.
Spatial	Pertaining to space - Changes that occur at the same time between different areas.
Standing Crop	The total quantity of fish present in any body of water at any particular time.
System	The river, its water, channel, channel materials, streambanks, and flora and fauna.
Temporal	Pertaining to time - Changes that occur over periods of time between different areas or within the same area.
Bedload Function	This terminology as used in this report refers to the stream or stream area capability of eliminating bedload sediment from its streambottom.
Surface Water	The water within the stream from the top of the water surface to the streambottom.
Subsurface Water	The water that is contained or moves through the materials of the streambottom. All water below the surface of the streambed.

APPENDIX V

Water Temperatures

Table 20 Summary of Water Temperature Data in The SFSR from The Stolle Area. 1962 and 1963. Degrees F.

MONTH	DAY	1962 TEMPERATURE MAXIMUM/MINIMUM		1963 TEMPERATURE MAXIMUM/MINIMUM	
JULY	12	56	50	56	50
	13	58	48	59	47
	14	56	46	57	49
	15	57	46	60	50
	16	59	46	55	48
	17	60	48	53	49
	18	59	45	58	49
	19	58	46	58	45
	20	60	48	58	48
	21	62	49	60	46
	22	63	51	60	48
	23	63	53	60	49
	24	62	54	60	52
	25	59	52	58	48
	26	55	51	58	44
	27	62	50	60	46
	28	60	50	60	47
	29	60	52	60	48
	30	59	51	60	46
	31	62	51	60	45
AUGUST	1	58	50	59	46
	2	62	54	59	44
	3	64	54	58	46
	4	54	47	60	48
	5	55	46	61	48
	6	57	46	58	48
	7	62	49	64	49
	8	61	49	66	50
	9	53	48	60	52
	10	58	47	64	52
	11	62	50	66	53
	12	64	50	60	52
	13	64	50	65	52
	14	65	48	63	51
	15	65	49	59	49
	16	64	48	63	49
	17	61	48	61	49
	18	62	49	60	47
	19	61	49	62	47

APPENDIX VI

Aquatic Macro-Invertebrates

Aquatic Macro-Invertebrates

Aquatic macro-invertebrates in the upper SFSR from physical study stations 1 through 40, takes in the main river from the headwaters to below the confluence of Buckhorn Creek. The aquatic insect studies were conducted by Robert L. Caskey.

The sampling consisted of taking two Surber net samples of 1 square foot each at each station from station 1 through 30 and also collecting at stations 36 and 40. The collecting was done during one season only (fall, 1971) and undoubtedly all seasons would have to be sampled to give a complete analysis.

The information in Table 20 summarizes the results and lists thirty-six separate breakdowns. Table 21 lists the species checklist. The species diversity of the SFSR is about the same as other streams we have studied.

Species composition and population distribution of the aquatic invertebrates of the upper portions of the South Fork Salmon River as determined by Surber sampling.

Station no.	1		2		3		4		5		6		7		8	
Sample	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Ameletus velox	74		1	34		4	7	9	3	4	2		8		7	5
Baetis bicaudatus	283	97	411	277	126	440	5	3	45	126	202	269	184	110	107	168
Cinygmula sp.	36	110	39	100	9	24	31	82	3	12	10	11	19	7	18	15
Epeorus grandis	8		22	1	4	6			2	3	5	53	1	3		1
Rhithrogena robusta		2	3		6	2		1	1	2	6	19	12	8	7	14
Paraleptophlebia heteronea	16	3	11	12	4	16	8	12		2	1	1	1			
Ephemerella hystrix	5		1		48	39			3						1	1
E. doddsi	7	3	4	6		2	3	2	1	5	1	1	2	1	2	1
E. grandis grandis																
E. spinifera			1				2	3					2	1	2	5
E. tibialis					1	8	2	3					2	1	2	5
Peltoperla sp.	22	23	26	9	2	7	1	2								
Nemoura spp.	26	23	10	2	10	34	5	6	1		6	5	4	6	5	6
Acroneuria californica	2	4		1		7	5		5	1	1	3	3	4	3	6
A. pacifica																
Arcynopteryx signata	10	3		6	3					1		4	2			1
Isogenus aestivalis				1	2	11	3									
Alloperla sp.	5	15	6	12	24	25	4	13	3	2	15	11	29	2	10	5
Rhyacophila angelita	1	3	3		1		1	1			1	2	3			1
R. bifila			2		1	1										
R. tucula					3	9					4					
R. vagrita											2	8				6
R. vao	9	3	8	1	7	14	2	2			15	9	2	1	3	7
R. vepulsa		7	2	5			2					1	6	5	4	13
Glossosoma sp.		2	3		6						1	9	1		1	1
Parapsyche elsis	2			1	3	3		1			1				4	2
Limnephilidae																
Lepidostomatidae																
Brachycentrus sp.							1									1
Elmidae		4		1	11	4	2	1		4	4		2		3	4
Chironomidae	115	74	101	99	8	2	6	11	7	3	11	6	7	6	6	9
Heleidae		1	2				2	1			4		2		3	4
Simulium sp.	4		1	1	33	29			1		1	1			1	
Tipulidae	1	8	1	3	3	1	1	3	1	1	1		3	1	2	2
Planariidae	57	10	28	12	49	29	1		1		7	5	1		1	
Annelida	215	119	161	139	185	181	9	35	20	35	131	143	85	45	13	12

Table 21 (cont'd)

Station no.	9		10		11		12		13		14		15		16	
Sample	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Ameletus velox		5				10		3	1	2						
Baetis bicaudatus	321	123	195	234	106	5	1	9	4	3	3	3	16	11	41	65
Cinygmula sp.	10	31	41	15	41	11	6	31	17	14	26	9	16	6	11	11
Epeorus grandis	20		1	8											1	
Rhithrogena robusta	21	12	18	22	11	1		5	1				19	8	11	10
Paraleptophlebia heteronea		9	5		1	10		65		1			3		1	2
Ephemerella hystrix	7		9	13									5			1
E. doddsi	6	2	7	4	2								1	1	5	1
E. grandis grandis							2	6	5	1		2	2	2	3	
E. spinifera	1															
E. tibialis	9	5	129	59	32	6	10	113	15	24	11	9	12	4	4	3
Peltoperla sp.																
Nemoura sp.	1	2	7	4				16	1						2	4
Acroneuria californica	4	1														
A. pacifica			2	2			6	4					2	1		
Arcynopteryx signata																
Isogenus aestivalis		2		3				3	1	4	1	3	3	1	1	1
Alloperla sp.	14	14	9	8	13	10	1	17	20	39	18	17	17	6	4	2
Rhyacophila angelita	8		2	4			1									
R. bifila																3
R. tucula																
R. vagrita			6	2	1											
R. vao		1	1				1									
R. vepulsa	1	2	5									1				
Glossosoma sp.			3	7					2		1	3	48	23	50	48
Parapsyche elsis			10	4	1			2					4		2	4
Limnephilidae	2	1								14	5	7	25	10	14	11
Lepidostoma sp.(?)	4		1	1				60	4		13	18				
Brachycentrus sp.	5		9	28			7	50		1		3	18	11	13	57
Elmidae	7		35	24	3		4	25	1		2	6	2	4	6	
Chironomidae	24	4	44	36	3	5	90	50	18	22	28	22	24	5	34	5
Heleidae	4		1				1	2				1	1	1		
Simulium sp.	2		4	54												
Tipulidae	16	2	60	36	1	2	41	17	20	1	12	17	12	6	26	
Planariidae													1			
Annelida	22				10	8		11	5	16	54	20	34	16	52	11

Table 21 (cont'd)

Station no.	17		18		19		20		21		22		23		24	
Sample	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Ameletus velox			*	*			4	4	2		4	8	6	2	1	
Baetis bicaudatus	62	108	*	*	54	45	1	2							5	14
Cinygmula sp.	41	5	*	*	13	18	14	12	16	6	19	12	4	7	7	14
Epeorus grandis	2	9	*	*	2											
Rhithrogena robusta	57	39	*	*	8	18	4	3								8
Paraleptophlebia heteronea	1		*	*			5	1	8	1	3	4	3			1
Ephemerella hystrix	2	8	*	*	4	1										
E. doddsi	5	6	*	*			1								2	6
E. grandis grandis			*	*	14	12	9	5	8	14	1	2	4		1	1
E. spinifera																
E. tibialis	4	2	*	*	16	13	1	1	7	7	4	3		1		
Peltoperla sp.																
Nemoura spp.																
Acroneuria californica																
A. pacifica		1	*	*												
Pteronarcella badia															1	
Isogenus aestivalis			*	*	2	1	2	1		1		3	1	1		
Alloperla sp.	47	27	*	*	7	2	20	23	9	3	3	7	10	9	7	11
Rhyacophila angelita																
R. bifila		2	*	*	11	1										1
R. tucula																
R. vagrita	1	5	*	*												1
R. vao		1														
R. vepulsa																
Glossosoma sp.	53	38	*	*	1	10	39	20	3	2			3		23	50
Parapsyche elsis	1	6	*	*	5		12	5						1	8	11
Limnephilidae			*	*	80	119	18	15	7	9	4	12		2		3
Lepidostoma sp.(?)							42	65	85	42	129	88	171	158	19	26
Brachycentrus sp.		15	*	*	77	50	192	67	5	4		1	2	11	10	3
Elmidae	17	36	*	*	87	67	31	29	22	54	18	18	14	14	20	25
Chironomidae	11	27	*	*	72	104	62	39	105	20	9	7	12		14	22
Heleidae	1	3	*	*	1	1	31	29		3	1					
Simulium sp.																
Tipulidae	7	14	*	*	44	58	23	14	25	13	9	13	13	7	2	1
Planariidae									2							
Annelida	83	80	*	*	14	42	21	18	6	16	4	5	19	13	74	69

Table 21 (cont'd)

Station no.	25		26		27		28		29		30		36		40	
Sample	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Ameletus velox		1	5							1						
Baetis bicaudatus	19	8	6	9	22	4	15	9	4	4	11	2	3		1	1
Cinygmula sp.	9	10	11	4	12	4	4	8	5	10	4	3	5	6	2	1
Epeorus grandis			1	1				1								
Rhithrogena robusta	1	2	1		5	2	12	13	12	3	5	14	2	4	1	2
Paraleptophlebia heteronea	1	1	1	1	5	1	2	1	1					1	1	5
Ephemerella hystrix				2	1			2								
E. doddsi				1	1		4	3			1					
E. grandis grandis	5	5	7	6	7	6	6	2	13	43	10	1	7		11	27
E. spinifera								1								
E. tibialis	5	10			2		1	1			12	2	6	5	1	1
Nemoura sp.																1
Acroneuria californica																
A. pacifica							1									
Arcynopteryx signata																
Isogenus aestivalis	3				1	2			1	3			3	10		3
Pteronarcella badia																1
Pteronarcys californica								3								
Alloperla sp.	2	2	1	7	4	11	21	9	8	14	7	8	24	36	5	6
Rhyacophila angelita																
R. bifila							4									2
R. tucula																
R. vagrita							2									
R. vao																
R. vepulsa					1	3										
Glossosoma sp.	13	8		22	25	11	18	33		27		5	8	36	6	5
Parapsyche elsis				38	1	5	39	38								4
Limnephilidae	9	6			29	6				4	2	1	7	4		
Lepidostoma sp.(?)	27	14	41	16	40	29	16	14	8	58	13	2	113	24	108	36
Brachycentrus sp.	14	9	3	71	42	29	60	65	8	24	7	1	5	30		61
Elmidae	27	50	30	11	27	18	16	13	72	88	1	2	14	5	11	8
Chironomidae	21	38	30	18	7	5	6	8	13	12	8	3	2	1	9	12
Heleidae				1							1					
Simulium sp.																
Tipulidae	16	19	22	26	25	23	23	22	26	45	4	4	7	2	33	33
Annelida	20	9	28	29	17	17	24	23	22	20	48	82	11	5	5	17
Planariidae							1									1

Table 22 Checklist of aquatic invertebrates collected in the South Fork Salmon River, September 22 to October 7, 1971.

EPHEMEROPTERA

SIPHLONURIDAE

Ameletus
velox Dodds

BAETIDAE

Baetis
bicaudatus Dodds
intermedius Dodds
parvus Dodds
tricaudatus Dodds

HEPTAGENIIDAE

Cinygmula sp.

Epeorus
(Iron) sp.
(Ironopsis) grandis (McDunnough)

Rhithrogena
hageni Eaton
robusta Dodds

LEPTOPHLEBIIDAE

Paraleptophlebia
heteronea (McDunnough)

EPHEMERELLIDAE

Ephemerella
sg. Caudatella
hystrix Traver

sg. Drunella
coloradensis Dodds
doddsi Needham
grandis grandis Eaton
spinifera Needham

sg. Ephemerella
(?) inermis [1]

[1] Nearly impossible to distinguish between nymphs of E. inermis and E. infrequens.

Table 22 (continued)

sg. Serratella
tibialis McDunnough

sg. Timpanoga
hecuba hecuba

PLECOPTERA

PTERONARCIDAE

Pteronarcella
badia (Hagen)

Pteronarcys
californica Newport

PELTOPERLIDAE

Peltoperla sp.

NEMOURIDAE

Capnia sp.

Nemoura sp.

PERLIDAE

Acroneuria
californica (Banks)
pacifica Banks

PERLODIDAE

Arcynopteryx
signata (Hagen)

Isogenus
aestivalis (Needham and Claassen)

CHLOROPERLIDAE

Alloperla sp.

TRICHOPTERA

RHYACOPHILIDAE[2]

Rhyacophila
angelita Banks

[2]Because of the lack of keys to Idaho species and the small size of the larvae, many specimens were identified only to genus and/or family.

Table 22 (continued)

Rhyacophila
- bifila Banks
- hyalinata Banks
- tucula Ross
- vagrita Milne
- vao Milne
- vepulsa Milne

GLOSSOSOMATIDAE

Glossosoma sp.

HYDROPSYCHIDAE

Parapsyche
- elsis Milne

LIMNEPHILIDAE

Dicosmoecus sp.

Limnephilidae genus unknown

LEPIDOSTOMATIDAE

(?) Lepidostoma sp.

BRACHYCENTRIDAE

Brachycentrus sp.

COLEOPTERA

ELMIDAE

DIPTERA

CHIRONOMIDAE

HELEIDAE (CERATOPOGONIDAE)

SIMULIIDAE

Simulium sp.

TIPULIDAE

Table 22 (continued)

OTHER INVERTEBRATES

TURBELLARIA

Planariidae

NEMATOMORPHA

Gordius sp.

ANNELIDA

Enchytraeidae

ARACHNIDA

Hydracarina